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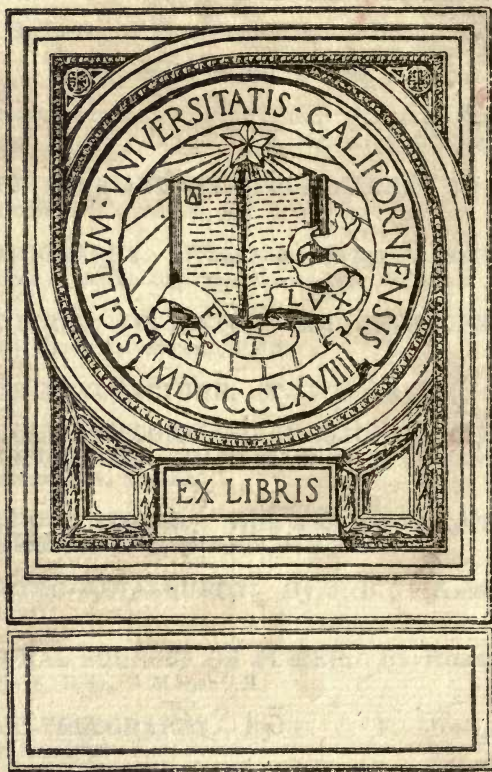
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BELLS, INDICATORS, TELEPHONES, FIRE AND BURGLAR ALARMS, ETC.

ELECTRIC BELLS

(1) THE ELECTRIC TREMBLING BELL

is one of the simplest and most useful pieces of electrical apparatus. Thanks to its simplicity it is apt to be treated with contempt by the average wireman; at least judging by the horrible examples one sees of bell fitting. Bell fitting can be reduced to a fine art if only a little common sense be brought to bear.

(2) CONSTRUCTION

An Electric Trembling Bell consists, essentially, of an **U** shaped electro-magnet; an armature, mounted upon a light flat spring; a contact maker; a hammer, and a gong. The electro-magnet comprises two bobbins of wire which encircle the limbs of an **U** shaped piece of soft iron, the coils being wound in such manner that when a current is sent through both coils in series the whole assumes the characteristics of a horse-shoe magnet, the extremity of one limb being North, and that of the other South polarity. Fig. 1 shows the general arrangement. The two inside ends are always joined together, as at X. By "inside" is implied the "commencing end" when the coils are wound, and great care should be taken with these, as should they by any means get broken the whole coil has to be re-wound to remedy

the defect. In the case of the outside end a breakage is not so serious, as it only entails unwinding the coil a turn or two until the requisite length is available for a repair.

(3) ACTION

From an examination of Fig. 1 there will be seen across the poles of the electro-magnet, mounted on

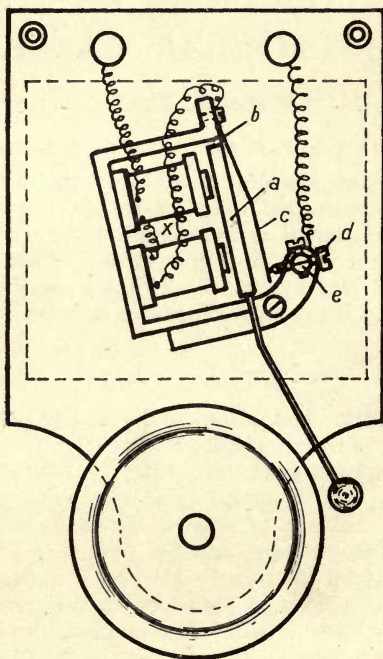


FIG. 1.

a light spring, secured, in turn, to a suitable bracket, a rectangular piece of iron, *a*, known as the armature, and it is an elementary fact that, if a current be passed through a coil of wire, wound upon an iron

core, and a piece of iron brought near it, there will be mutual attraction ; so that, if we mount our piece of iron, or armature, upon a light spring, *b*, which normally tends to keep it away from the pole pieces, immediately a circuit is completed through the coils and current flows, the armature will be attracted. If, now, we break the circuit, the armature will fly back, owing to the set of spring *b*, so that what happens is this—the attraction of the electro-magnet overcomes the tension of spring *b* on which the armature is mounted, whilst the current is flowing : directly the circuit is broken, however, the attraction ceases, and the spring draws the armature back from the pole pieces.

We will now consider how the circuit is automatically made and broken by the armature itself. Again referring to Fig. 1, we see that on the armature is mounted a second light spring, *c*, fitted with a platinum, or, in the case of cheaper bells, silver contact ; this normally rests on the adjustable contact screw *d*, which is mounted in the brass pillar, *e*. Tracing out the circuit, it will be seen that one of the outside ends of the coils is connected to one terminal of the bell, and the other to the bracket on which the armature is mounted ; whilst the remaining terminal is joined to the brass pillar *e*, which carries the contact screw. If a battery be connected to the bell terminals, a current will flow through the coils, to the armature ; thence by way of spring *c* to the contact pillar *e*, and back to the battery. As there is thus a complete circuit through the coils, the armature will be attracted, and the contact between spring *c*, and the adjustable screw, *d*, in the contact pillar *e*, broken in consequence. No current can then flow from the battery, therefore the attraction of the electro-magnet will cease, and the armature will be pulled back from the pole pieces by spring *b* upon which it is mounted. This return movement again brings spring *c*, on the armature, in contact with

screw *d* on the pillar, and re-establishes the current through the coils, with the result that the armature is again attracted, and so on; thus the action of making and breaking the circuit is performed automatically by the bell itself. Consequently, if we fix a stem into the end of the armature, with a weight attached to its free extremity, and arrange a gong in a suitable position relative to the weight, every time the armature is attracted the gong will be struck, and, as a succession of strokes is given at short intervals, a loud and continuous sound is produced so long as current is permitted to flow.

We will now consider the various modified types of bell likely to be met with in installation work.

(4) TREMBLING BELL FITTED WITH INDICATOR

This class of bell is used to indicate that a ring has been received in the absence of the person wanted, so that the latter is thus informed that some one has rung, and can make the necessary inquiries upon his return. The indicating portion may be restored either electrically, or manually; usually the latter. In this case a small silk cord hangs from one side of the bell, and replaces the indicator when pulled.

(5) CONTINUOUS RINGING BELL

This type of bell is frequently used in conjunction with fire and burglar alarm contact devices; also for calling servants, etc. For the above purpose it has this advantage, that, when once the push-button has been actuated, the bell continues to ring until checked by pulling a small cord which, as in the last type described, depends from one side of the bell. This closely resembles the ordinary type of trembling bell, the difference consisting in the addition of a third terminal, a trigger, and a second contact pillar. Its principle of action is as follows. Normally, the trigger rests upon an extension of the bell armature, and, when the latter is attracted, it

releases the trigger, which makes contact with the second pillar, thus closing a circuit which functions in exactly the same manner as if the push-button were depressed continuously. To stop the bell ringing, a small cord attached to the far end of the trigger is pulled down, and restores the latter to its normal position.

If it be desired that the bell shall not ring continuously, all that is necessary is to insert a switch in the wire coming from one pole of the battery to terminal No. 3. In some cases this switch is used to throw in the continuous action during the night only. In the daytime the switch disconnects the continuous action gear, and the bell rings normally; i.e., only so long as the push-button is depressed.

(6) SINGLE-STROKE BELL

This pattern is largely used by railway companies for block signalling, etc. It is also employed on tram-cars, and in mines. In action, the only essential difference between it and the ordinary trembling bell is that instead of the armature giving a rapid succession of blows when the push-button is depressed, one blow only results for each time of closing the circuit, the armature remaining attracted until the circuit is broken by releasing the push; so that this bell is admirably adapted for Morse signalling.

Fig. 2 shows a pattern of single-stroke bell suitable for use on tram-cars: the armature is restored by gravity, the bell being fixed in the position shown in the figure. The armature, *a*, is pivoted between the two cock-pieces, *b* and *c*, and to it is attached a light rod *d*, carrying at its free end a hammer *E*, which strikes the inside of a circular gong when the armature is attracted. The dotted circle indicates the position taken up by the gong, the whole of the working parts being enclosed within it. A variety of patterns of single-stroke bell is made, but the principle of action remains the same in each case.

(7) CIRCULAR PATTERN BELLS

Several patterns of trembling bell have been introduced by manufacturers from time to time, in which the coils, armature, and mechanism generally, are enclosed within, or protected by the circular gong. In theory, such a disposition of parts makes for an

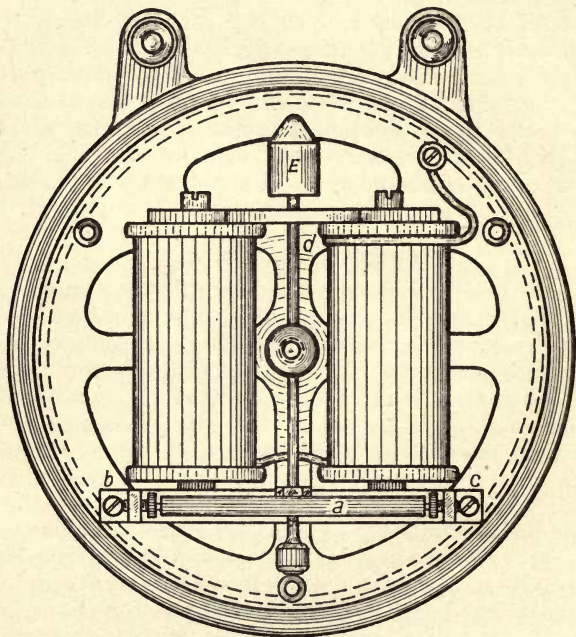


FIG. 2.

extremely neat and pleasing design, taking up minimum space, and obviating the necessity for a separate wood or metal cover to protect the coils, etc.

In practice, however, there is one vital disadvantage, viz., the limitation imposed upon the length of the hammer stem, and the consequent inefficiency

of the bell as a sound producer. In the larger diameter bells, where the hammer stem can be bent round into an arc, and thus given a certain amount of natural spring, this drawback is not so noticeable as in the smaller patterns of circular bell—up to, say, 3 in. In these a short stumpy hammer stem is arranged to strike upon an internal lug, projecting radially inwards from the rim of the gong, and such bells, apart from the difficulty in effecting satisfactory adjustment of trembler, contacts, and hammer, seldom give satisfaction.

The only really successful type of small circular trembling bell yet marketed, is that known as the "Parapole." It is made by Messrs. Gent & Co., of Leicester, and its constructional features are outlined in Fig. 3, which represents a plan of the com-

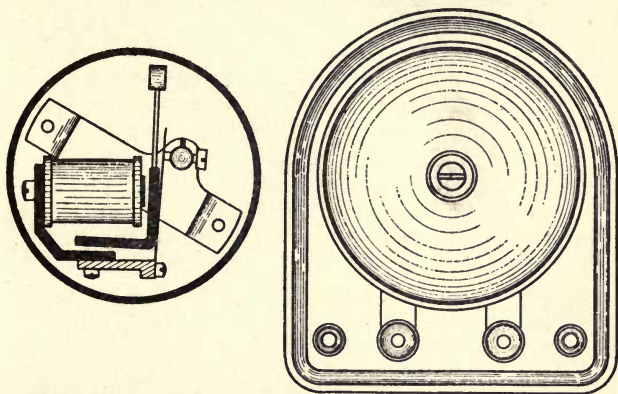


FIG. 3.

plete bell, with gong in position, together with a diagram of the internal mechanism.

It will be seen that only one coil is used to energize the electro-magnet, whilst the armature is a right-angled piece of soft iron which, when attracted, bridges air gaps in two different planes, instead of

as in the ordinary pattern, one single plane. Its great advantage centres in the fact that the armature and hammer stem combined may be nearly the length of a diameter of the gong, thus making for greater flexibility, and a more efficient ring.

(8) PUSH BUTTONS

Bell push buttons all perform a similar function, viz., to bridge two points in a circuit, which are normally out of contact with one another. To this end, pressure is applied to a button of insulating material, and the circuit, thus closed, is automatically opened again when the pressure is released. A suitable means of accomplishing this is through the medium of two springs, mounted upon an insulating base, the springs being secured to the base by screws, which also constitute the terminals for attachment of the wires. Three holes are also provided, two for fixing the base to the wall, and a third to accommodate the wires; in this connexion, care is necessary to see that the main fixing screws are well clear of the contact springs. The holes for the wires should be in the most convenient position for connecting the latter to the terminals. A suitable cover is provided, in the centre of which is drilled a hole, through which the actual push-button projects, a shoulder being left at the bottom of the button to prevent the latter falling away. The base of the button normally rests on the top spring.

An almost endless variety of designs of push-button can now be obtained, in wood, porcelain, brass, phosphor bronze, and antique copper, ranging in price from 3*d.* to several shillings.

(9) TYPES OF PUSH-BUTTON

Push-buttons may be roughly classified as follows :

- (1) Ordinary Push, Single and Multiple.
- (2) Pear-shaped Push.
- (3) Morse Key Push.
- (4) Bell Pull.

(10) THE MULTIPLE TYPE

consists of two or more single push-button equipments mounted upon a common base, and is very convenient for use in flats, so that any floor may be rung from one central position; also in large offices, to enable the principal to call the attention of several departments at will. These multiple pushes may be so arranged that slips or labels can be inserted, bearing the name of the department, opposite the button corresponding therewith. A typical design is shown in Fig. 4.

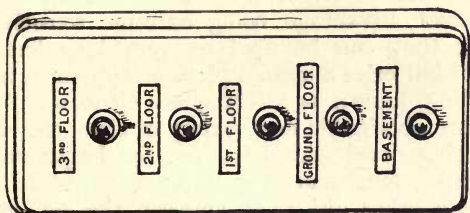


FIG. 4.

(11) PEAR-SHAPED PUSH-BUTTON

This pattern is generally used in bedrooms connected to a length of twin flexible wire, which either hangs by the bedside, or enables it to be placed under the pillow. It is also largely adopted in connexion with portable bell sets, for use in sick-rooms and other places where a means of signalling may be only temporarily required. See Fig. 5.



FIG. 5.

(12) BELL-PULLS AND ADAPTORS

These are obtainable for attaching to the old style of crank bell wires, so as to enable the existing

pulls to be retained in service. They are also sometimes used where the old-fashioned bell pull is preferred to the more modern push-button. They are also largely employed in collieries and damp situations, and under circumstances where they are called upon to withstand rough usage. For this duty they are usually enclosed in strong cast-iron cases. A typical example of a bell pull for mining work is shown in Fig. 6.

(13) POLARIZED BELLS

These are actuated by an alternating current, their chief advantage being extreme sensitiveness, so that they can be used on very long lines. In place of batteries a special piece of apparatus is used for calling, known as a "Magneto Generator." The latter are obtainable in a variety of sizes, the smaller ones being fitted with two, and the larger patterns with three, four, and even five permanent magnets. The only other difference between the smaller and larger or more powerful generators is that in the former the armature is usually wound to a high resistance for ringing a number of bells in series, whilst the latter are generally of lower resistance, thus enabling them to yield the comparatively large current necessary to ring a number of bells connected in parallel.

(14) THE MAGNETO GENERATOR

is really a small alternator, permanent magnets being used to create the field, instead of the more familiar electro-magnet. Experiment shows the neighbourhood of every magnet to be permeated by a mysterious something, familiarly known as "lines of magnetic force," and, further, if a wire be moved in the vicinity of a magnet in such manner as to cut these lines of force, a current will be induced in that wire. The electromotive force of this induced current depends upon the speed with which the wire passes through, or cuts the lines of force, and also

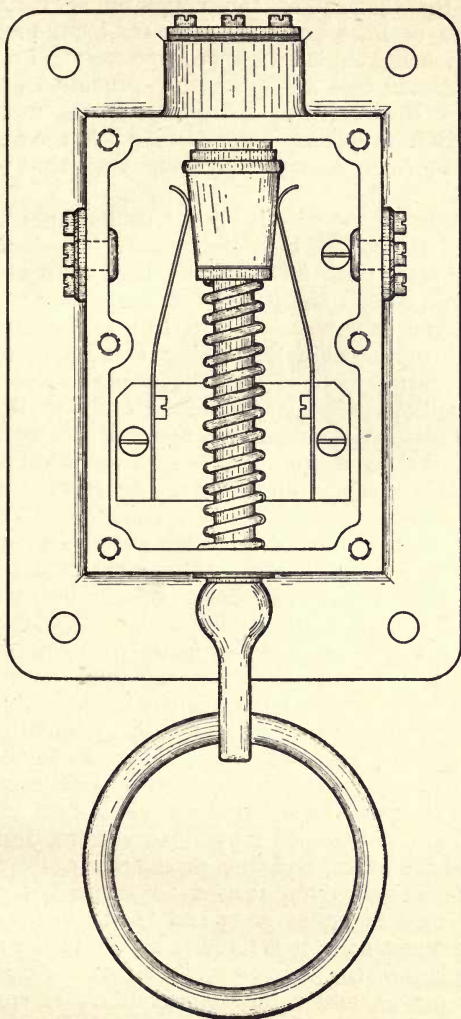


FIG. 6.

upon the density of the magnetic field (i.e., the number of lines per unit cross-sectional area). In the preceding explanation we have assumed only one wire, formed into a loop so as to provide a complete path for the current. If we increase the number of turns by forming a coil, and placing it in the magnetic field, we can considerably augment the induced E.M.F.

In practice the wire is always wound upon an iron core, of **H** section, inasmuch as the latter affords a much better path for magnetic lines than air. For the same reason the permanent magnets are invariably fitted over pieces of soft iron known as "pole shoes," the combination being bored out to very nearly fit the iron core of the armature, such that the complete magnetic field includes as small an air-gap or gaps as possible, thus increasing its efficiency.

A good three-magnet generator should ring a 1,000-ohm bell through an external series resistance of 60,000 ohms.

The cross-section of a magneto generator appears as shown in Fig. 7, which also includes a skeleton diagram of a polarized bell. It will be seen that the latter consists essentially of the following parts : a pair of iron-cored coils, mounted upon an iron yoke ; a light armature pivoted immediately over the two coils ; fixed to the centre of the armature a stem, on which is mounted a ball, to constitute the bell hammer ; and two gongs, disposed one on either side of the hammer, and in such a position relative thereto that when the armature is attracted to either pole tip, the hammer moves to and fro, from one gong to the other, and thus produces a characteristic ring, in which, given correct adjustment, the individual tone of either gong can be distinctly heard. A permanent magnet is fixed as shown in the figure ; this polarizes the armature, inducing a North pole at the centre, and a South pole at either end (i.e., assuming the polarity of the magnet to be as shown

in Fig. 7). The other pole of the magnet induces North polarity in the centre of the iron yoke upon

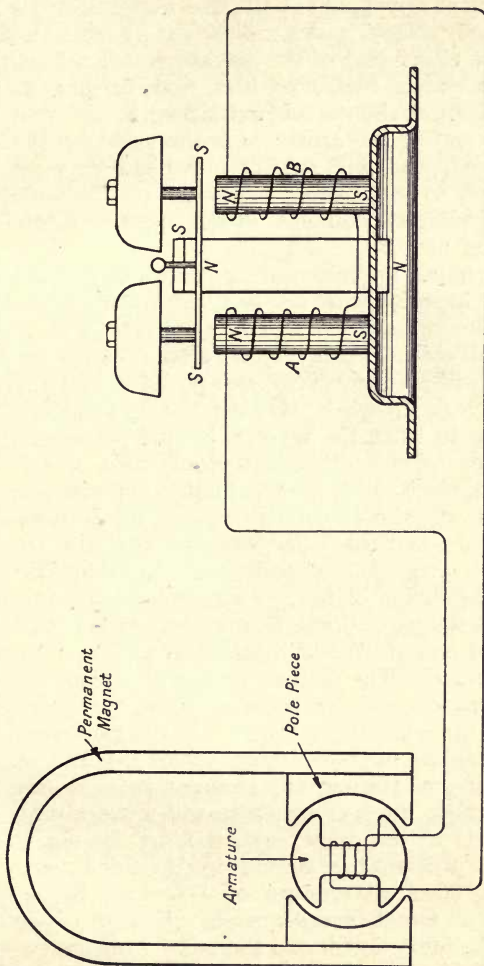


FIG. 7.

which the coils are mounted, and South polarity at the originating ends of the two core irons on which the coils are wound; both free extremities are consequently North poles. Now, as there is a South pole at either end of the armature and a North pole at the end of each core iron, and, further, as these are of approximately equal strength, the pull upon either end of the armature is the same, so that it is balanced, and will remain in whichever position it happens to be placed. It should also be noted that the winding on coil *A* is in the opposite direction to that on coil *B*.

If, now, an alternating current generator be joined in series with the bell, as shown in the figure, and the armature rotated, a current will traverse the bell coils. For every revolution of the armature there will be two waves, one positive, and the other negative. If, when the generator armature commences to turn, the wave is in such a direction that it tends to strengthen the North pole of coil *A*, it follows, since coil *B* is wound in the opposite direction, that it will simultaneously weaken the corresponding North pole on this coil. Consequently the armature will be attracted towards coil *A*: With the next half revolution of the generator armature the direction of the current will be reversed, so that the North pole of coil *A* will be weakened, and that of coil *B* augmented. The bell armature will thus be attracted in turn towards coil *B*, and cause the hammer to strike the gong on that side. As the generator armature makes approximately 1,000 R.P.M., and the direction of the current changes twice during each revolution, the bell armature will move rapidly from one side to the other, and, striking the gongs alternately, will produce a loud double-noted ring.

The chief advantages of Polarized Bells are as follows. Great sensitiveness, absence of contacts and the faults incidental thereto. Also the generator can yield a much higher voltage than it would be

practicable to obtain from batteries, and there is an almost entire absence of maintenance costs when once installed. A complete Polarized Bell movement, as it appears prior to fitting in a containing case, is shown in Fig. 8.

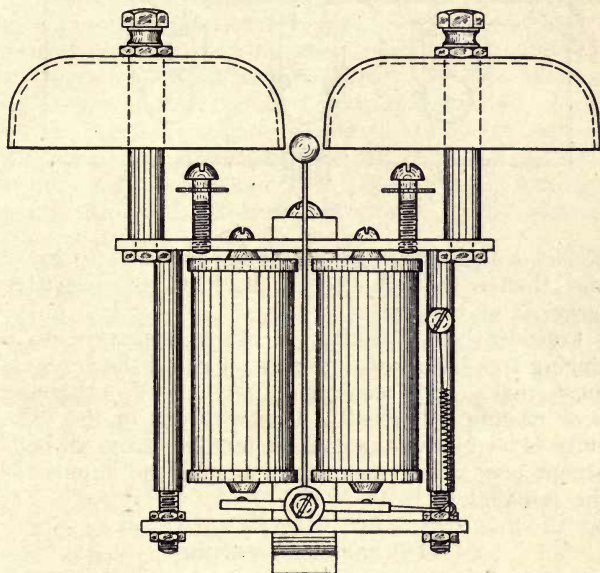


FIG. 8.

ALTERNATIVE METHODS OF CONNECTING BELLS, BATTERY, AND MAGNETO GENERATOR

There are two fundamental ways of connecting bells in circuit with a battery or generator, viz. (1) Series; and (2) Parallel.

(15) SERIES METHOD

Fig. 9 shows three trembling bells connected in series. It will be seen that there is only one path for the current; starting from the positive side of the battery, through the push contacts, to terminal

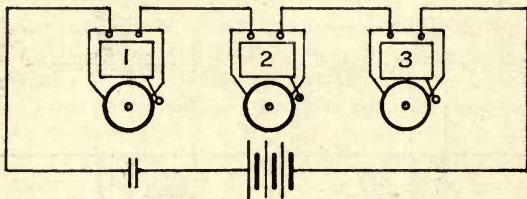


FIG. 9.

of No. 1 bell, from the remaining terminal to No. 2 and thence through No. 3, back to the negative terminal of battery.

Considerable difficulty is often encountered in ringing trembling bells in series, since all the contacts must make and break simultaneously; otherwise poor ringing will result. One way out of the difficulty is to remove the contact breakers from all bells except one, which makes and breaks the circuit for the remainder.

(16) PARALLEL METHOD

This gives the better results in practice. Fig. 10

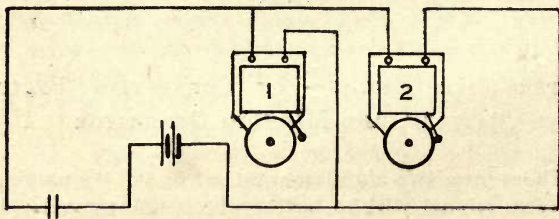


FIG. 10.

shows two bells joined in parallel. If this diagram be studied in conjunction with Fig. 9 it will be seen that there is a complete circuit through either bell, independent of the other, so that, should a fault develop in No. 2 bell, No. 1 can still be operated, and vice versa; whereas, in the series arrangement, should a breakdown occur in any one bell, all are thrown out of use for the time being. Another advantage is that the armatures need not be adjusted to make and break simultaneously, as each bell has its own trembler action, and is independent of the other; also a smaller number of cells may be employed, as the joint resistance of two bells in parallel is only half that of one bell. In the series arrangement the total resistance in circuit is the sum of the resistances of all the bells.

When the parallel arrangement is adopted care should be taken to see that all bells have approximately the same resistance, as, should a high resistance bell be joined in parallel with one having a very low resistance, the latter will divert practically all the current, and the former will not receive enough to produce an efficient ring.

(17) BELL CIRCUITS IN COMMON USE

Fig. 11 shows the simplest bell circuit possible, as, e.g., a bell to be rung from the front door, and to

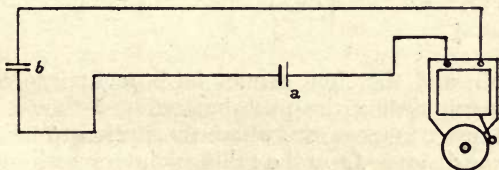


FIG. 11.

signal in the kitchen of an ordinary villa residence; *a* represents the battery, and *b* the push-button.

Fig. 12 shows how a bell can be rung from four different points in a building, by depressing any one of the push-buttons, 1, 2, 3, or 4. If the circuit be traced out from the positive pole of battery, through

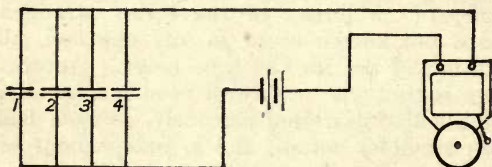


FIG. 12.

the bell, it will readily be seen that if any one of the pushes be actuated the current path is completed, and the bell will ring.

Fig. 13 indicates how two bells, located in different parts of a building, may be rung independently by means of a switch. For instance, should it be desired to ring No. 1, the switch is thrown over to the left-hand stud, and vice versa. It will be seen that whilst ringing either bell the other is disconnected at the

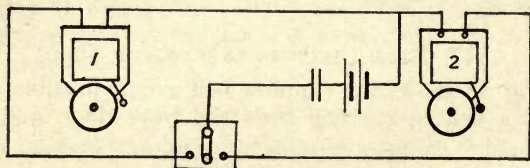


FIG. 13.

switch, and therefore cannot be brought into circuit by manipulating the push-button.

In order to save wire where the station to be called is some distance from the calling point, or push-button, the earth is used as a return instead of a second metallic conductor. In such instances it is usual to employ what is known as a "relay." This resembles a bell movement, without the usual hammer,

but provided with a suitable contact, which is closed when the armature is attracted. The latter is so pivoted as to swing very freely, and a light adjustable antagonistic spring is employed to keep it in the normal position. This piece of apparatus is several times more sensitive than the bell; consequently, only a fraction of the usual battery power is necessary to operate it. The bell to be rung is joined in a local circuit, which is normally open when the relay is inactive, but is closed by the attraction of the relay armature, so that the relay in reality functions as an electro-magnetic push-button or switch.

Fig. 14 is a diagram of the connexions. When

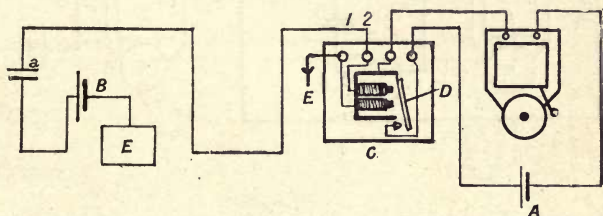


FIG. 14.

the circuit is completed by pressing the push-button *a*, current flows from the positive terminal of battery *B*, along the line to No. 2 terminal of the relay, through its coils, and out by way of No. 1 terminal to earth; thus back to battery. The armature is attracted, and makes contact with *c*. A circuit is then completed from positive terminal of local battery *A*, through contact *c*, armature *D*, and bell, to the negative pole; consequently the bell rings so long as the button is depressed.

Fig. 15 illustrates a circuit used when it is necessary to ring two separate bells, each controlled by its own push-button, from the same battery. For instance,

one bell might signal a call from the second floor of a building, and the other from the ground floor; in this case different types of gong would be employed, so that a distinctive ring can be given in each case. The circuits are as follows. Assume push-button *A* to be depressed; a current then flows from the positive pole of battery, along the line, through bell No. 1, to negative pole; thus completing the circuit and ringing No. 1 bell. To ring No. 2 bell, push-button *B* is depressed; a current then flows from positive of battery, along the line, through push-

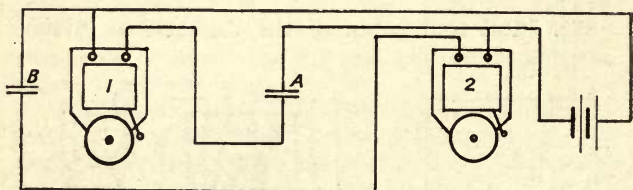


FIG. 15.

button *B*, and bell No. 2, back to negative of battery. Should both push-buttons be actuated simultaneously, both bells would ring.

Except when code ringing is required, as in railway practice, it is preferable, whenever the distance exceeds a few hundred yards, to use magneto bells, as in battery ringing it is essential to provide a good earth return, a matter not quite so easy of accomplishment as it appears in the diagram. Should the earth contacts be indifferent, the comparatively low voltage of the battery is unable to overcome the resistance of the circuit, and trouble results; whereas a good magneto generator will easily ring a polarized bell through anything up to 60,000 ohms, and a fairly high resistance earth will not appreciably affect the ringing.

(18) POLARIZED MAGNETO BELL CIRCUITS

Fig. 16 represents the simplest form of circuit, a bell and generator being fitted at each station, and connected in series with the line. If No. 1 wishes to ring No. 2, he simply gives the generator handle a few turns, thus sending an alternating current along the line, and ringing No. 2 bell. There are two alternative ways of arranging the combined sets at either station: (1) such that when No. 1 rings out he rings his own bell, and also the bell at the far end of the line; (2) so that he may automatically cut out his own bell when operating the generator, and ring only the one bell at the distant station. Either method may be adopted in practice; theo-

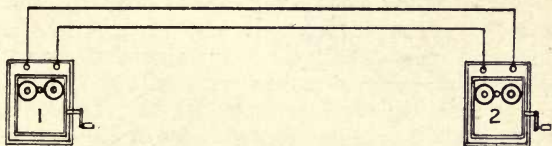


FIG. 16.

retically, it is better to cut out the bell at the calling station, as its resistance may be anything from 100 to 250 ohms, which of course diminishes the available generator current. On the other hand it is sometimes preferable to leave the home station bell in circuit as an audible indication that current is actually passing out to line.

It will be seen that as the generator and bell are in series with each other, the generator armature offers a considerable resistance to current flow (they are usually wound to about 500 ohms for series working). When the armature is at rest, therefore, it is bridged by a short-circuiting device, which is automatically opened immediately the generator handle is turned.

(19) AUTOMATIC CUT-OUT OF MAGNETO GENERATOR

When a magneto generator is installed in conjunction with a bell at each station, it is usually placed in series with the bell and line wires; consequently, the resistance of the armature would, under ordinary circumstances, be in circuit when the bell is rung by a distant station. This is a very undesirable feature, as the resistance of such an armature is usually in the neighbourhood of 500 ohms. To enable this idle resistance to be short-circuited when the home generator is out of use, the automatic switch was introduced. One of the best forms of this device is shown in Fig. 17.

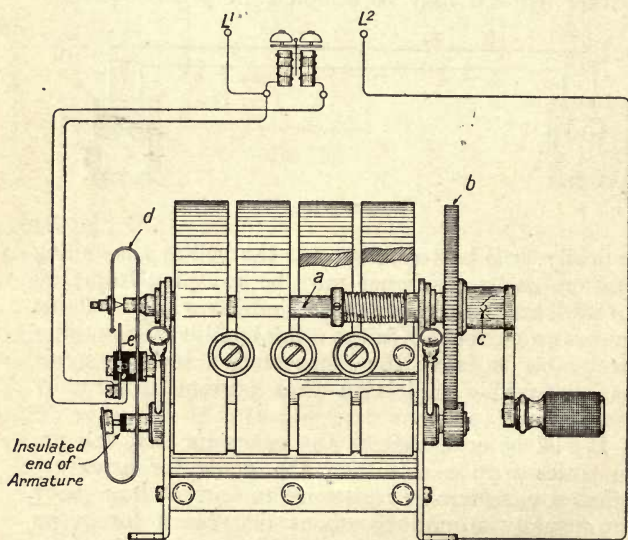


FIG. 17.

In winding the armatures of magneto generators it is the usual practice to join one end of the winding

to the armature itself, the other being threaded through the shaft, and insulated. On reference to the figure it will be seen that a steel shaft, *a*, runs through both the end plates which constitute the bearings. On this shaft is loosely mounted the large driving wheel, *b*, one end of the centre boss of which has a V-shaped recess; a steel pin is fixed in the shaft as shown at *c*. Encircling the shaft, and free to move laterally upon it, is a spiral spring, one end of which abuts against the inside of the end plate, whilst the other is held in position by an adjustable collar, fixed by a small set screw, so that, by moving the collar, the tension of the spring can be varied as required.

On the other end plate of the generator, but insulated from it, is mounted a specially shaped contact spring, *d*, which bears upon a stud connected to the insulated end of the armature winding. Another short spring is also fitted, and is insulated both from the frame, and from the spring *d*. This latter spring is not used unless it is desired to cut out the local bell when the home station is calling. This, however, is a desirable feature since the only resistance then left in circuit with the generator is that of the line and the bell at the distant end.

We will now consider the action of the shunt. Imagine a current from the distant station entering at line 1 (*L1*); it flows through the bell to spring *d*, and to the insulated end of the armature winding. There is then a path through the armature to *L2*, but, when the generator is at rest, as shown, the shaft *a* is in contact with spring *d*, so that the current, instead of flowing through the high resistance armature, will take the path of lowest resistance, through the shaft to frame, and thence to *L2*.

Conversely, when the home station is calling, and the handle of the generator is turned, the pin *c* rides up the V groove, against the tension of the spiral spring; consequently the shaft *a* is drawn outwards,

and breaks contact with spring *d*, so that the latter now makes contact with spring *e*. The current then flows from spring *d*, to *e*, and out to *L1*; through the distant station, back to *L2*, and thence to the other end of the armature which is connected to frame, thus completing the circuit without including the bell at the calling end.

If it is desired that the bell at the home station shall ring also, it is only necessary to disconnect the wire from spring *e*.

There are various other methods of performing this function automatically, but the governing principle remains the same in all.

A number of polarized magneto bells may be joined in series, limited only by the capacity of the generator; as many as 20 bells, each of 100 ohms resistance, may be thus installed, provided the line be not too long. Bells for series working are usually wound to a resistance of 100 ohms apiece, and a good generator should easily ring one of these bells through an extra series resistance of 10,000 ohms.

Fig. 18 shows three bells joined in series in the

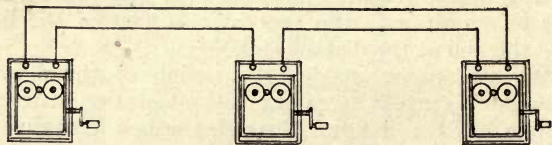


FIG. 18.

same pair of lines. If more bells be required it is only necessary to cut one of the lines, and connect the two free ends of the wire to the two terminals of the bell. When more than two stations are connected on one line, or pair of wires, it is necessary to introduce "code" ringing, i.e., a distinctive number of short rings, with intervals, for each station.

Figs. 16 and 18 shows a combined generator and bell at each station; this may not be necessary in

every case. Thus, Fig. 19 shows a circuit in which one station only is fitted with a generator, being thus able to call the other three stations, whereas

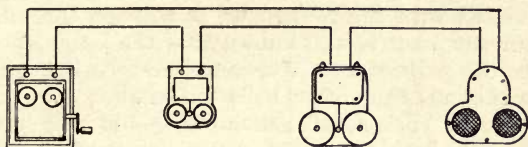


FIG. 19.

they are unable to call, being fitted with bells only. In this circuit all the bells are connected in series.

Fig. 20 depicts a similar arrangement of one calling

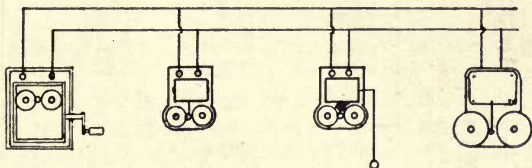


FIG. 20.

and three bell stations, the difference between it and the preceding one being that the bells are joined in parallel; i.e., two line wires are run between the stations, and the bells simply bridged across them.

When it is required to ring a large number of bells in parallel, a special type of magneto generator, known as a "bridging" generator, is employed, the differences between it and the "series" generator being that the armature of the former machine is wound to a lower resistance (sometimes as low as 50 ohms) and, generally, four or five magnets are employed to create the field. Bells for parallel working are also wound to a higher resistance (1,000 to 1,600 ohms).

It is necessary when joining bells in parallel, to see

that they are all of the same resistance, as the current flowing along the line from the calling station is supposed to split up equally amongst all the bells. Should one of them offer a very low resistance as compared with the remainder, it will rob the others of current, as it is well known that the latter always takes the path of least resistance, and, consequently, poor ringing of the other bells will result.

A good "bridging" generator should ring thirty 1,000 ohm bells connected in parallel, through a line resistance of 1,000 ohms.

Fig. 21 shows how two groups of bells may be rung

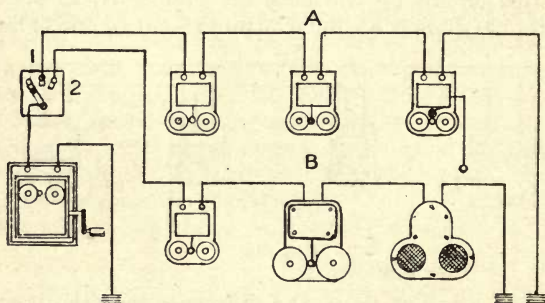


FIG. 21.

independently by means of one generator. The two lines terminate in the two contacts of a two-way switch, the lever of which is connected to one side of the generator; the other terminal of the generator is earthed. The distant ends of the two lines are also earthed. When the switch lever is placed on No. 2 contact, and the generator handle turned, the three bells on the B line are rung, the current flowing from the generator, through the lever of the switch to No. 2 contact, along the B line, through the three bells in series, and back, through the earth, to the other side of the generator. Similarly, if it is required

to ring the three bells on the A line, the switch lever is placed upon No. 1 contact, and the current then flows along the A line, through the three bells, and back to the generator through earth.

Fig. 22 shows a combination of trembling and

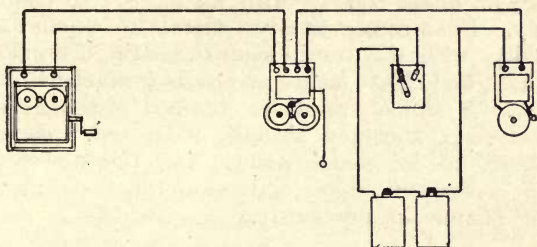


FIG. 22.

magneto bells. This arrangement is suitable for ringing over a very long line, as the high voltage of the generator, and the sensitiveness of the polarized bell are admirably adapted for this purpose. The magneto bell is fitted with a shutter, which is normally held up by the bell hammer; when the hammer is actuated the shutter falls, and, by so doing, closes a local battery circuit through the trembling bell, causing it to ring until the shutter is replaced by the attendant. A switch is inserted in the local battery circuit for cutting out or disconnecting the trembling bell when not required. The arrangement is very suitable for an office, as, during the day, the magneto bell is sufficiently loud when any one is in attendance; whilst at night a loud ringing trembling bell may be used, located outside the office, in a position where it may readily be heard some distance away, as by the night watchman for example.

(20) FIRE ALARM APPARATUS

The majority of fire alarm contact devices depend for their action upon the expansion of metals when

subjected to a rise of temperature. In some forms a composite strip is used, made up of two metals having dissimilar coefficients of expansion. The two strips are firmly secured together at both ends, one of which is fixed, whilst the other is arranged to make or break contact with an adjustable contact screw. Heat causes the two metals to expand unequally, with the result that the strip distorts or buckles, and either makes or breaks contact with the screw. A similar result is obtained with a single metal strip, anchored at both ends, and a contact arranged at its centre point. The bowing of the strip consequent upon expansion functions in the same manner as previously.

(21) "AERO" FIRE ALARM SYSTEM

A later and very ingenious fire alarm system, known as the "Aero," and exploited by Messrs. L. E. Wilson & Co., of Manchester, makes use of the expansion of air. A system of small bore copper tubing is installed throughout the premises to be protected, and coupled up to a central closed chamber or series of chambers, each fitted with a flexible diaphragm, carrying a contact-making device. Increase of air pressure within the system, set up by local heating of the tubing at any given point, raises the air pressure in the corresponding chamber. This forces the diaphragm outwards, causing the contacts to operate, and thus complete an alarm bell circuit. Provision is made for gradual expansion, such as would ordinarily occur with the normal temperature changes during the day or night, or with the seasons; in the shape of leak valves, which permit air to pass into or out of the system at such a rate that the alarm will remain unaffected save by a sudden or abnormal rise in temperature.

So far as the wireman or installer is concerned, these various alarm contacts and devices are sup-

plied, or can be purchased, complete and ready for fitting, the only part he is called upon to play being to fix them securely in the positions chosen for their reception, and connect his service wires to the terminals provided.

(22) FIRE ALARM CIRCUITS

There are two alternative methods of working either a fire or burglar alarm installation; viz., "open" and "closed" circuit. Under the former the alarm is given by the contact devices automatically closing a circuit which includes a bell or other indicator, and the necessary battery. This system is fairly reliable, but calls for systematic testing and inspection to ensure that it is in thorough working order at all times.

With the "closed" circuit or permanent current system, on the other hand, the various alarm contacts are normally closed, and current is always flowing in the main circuit, which includes a relay winding. The relay is normally energized, and holds its armature permanently against the pole pieces. Should a contact break, or a wire be cut or disconnected at any point in the system, the current is at once interrupted, the relay armature falls back under tension of a spring, and, by so doing, completes a local alarm bell circuit.

It will be seen that this latter system, although involving a greater current consumption than the former, is far more reliable, in that it is self-testing at all times, any disconnexion being at once signalled by the ringing of the alarm bell. Closed circuit working entails a slightly higher grade of insulation on the line wires, owing to the constant potential which exists between different points, and might in time set up leakage were the insulation at all weak or defective.

A typical closed-circuit burglar alarm system, equally applicable to fire alarms, is shown in Fig. 23.

(23) BURGLAR ALARM CIRCUIT

A simple but efficient burglar alarm system is shown in Fig. 23; it is arranged on the *closed circuit* principle, i.e., the circuit, including relay R , battery BA , contacts C and C^1 , and switch S , is closed during such time as the installation is in service for the protection of a building from burglary, and a permanent current flows all the while. The principle of action is as follows; when the switches are closed, the armature of relay R is attracted, and held until contact C or C^1 is opened, as by the opening of a door or window to which it is attached. Similarly, the circuit may be opened by the cutting or fracture of a wire forming any part of it. Immediately this takes place the relay coils are de-energized, allowing the armature to fall back and close the alarm bell circuit, the bell B continuing to ring until switch S^1 is operated. The battery BA , in the alarm circuit, should be fairly large (say 4-6 block agglomerate cells) in order to yield a steady output for several hours. Battery BA^1 , on the other hand, may consist of two pint-size Leclanché cells (No. 2) these being required for ringing the alarm bell at infrequent intervals and

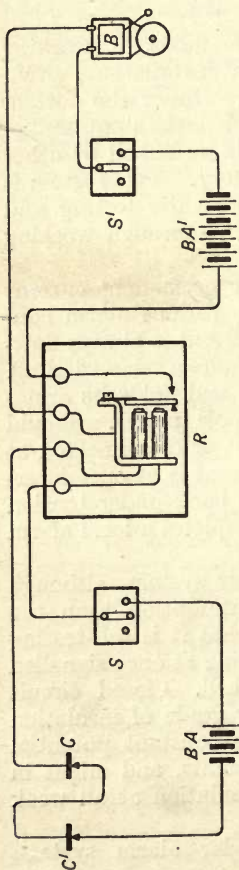


FIG. 23.

for short periods only. The relay winding should be of high resistance (say 1,000 ohms). When the system is out of use, as e.g., during normal business hours, switches S , and S^1 should be left open.

(24) CIRCUIT FOR CONTROL OF BELL AT A DISTANCE

It is often the case in a system embracing a continuous ringing bell, or even one of the ordinary pattern, that the distance from the bell to the actuating pushes or contacts is greater than the usual run of bell circuits; or that the bell itself is a large one, requiring considerably more than the usual line battery current to energize it. In such instances a relay is introduced into the line circuit, which, when operated, closes a local circuit including the bell, and, if necessary, a separate battery of sufficient capacity to ring the bell efficiently. Such a circuit is shown in Fig. 24 where R is the relay, BA the calling battery, BA^1 the local bell battery, C the contacts or pushes, and B the bell.

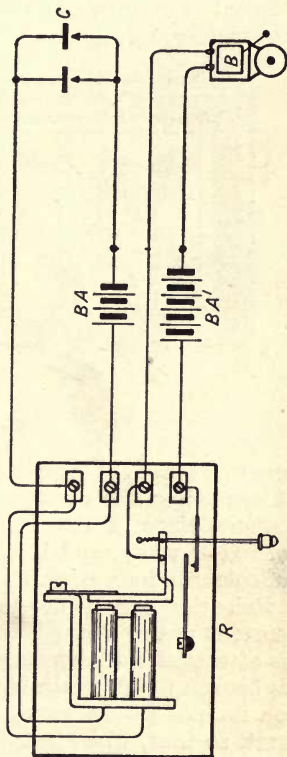


FIG. 24.

(25) INDICATOR MOVEMENTS

There are three main classes of Indicator Movement :

- (1) Pendulum indicator.
- (2) Drop Indicator ; Manually Restored.
- (3) Drop Indicator ; Electrically Restored.

(26) PENDULUM INDICATORS

are made in a variety of patterns, Fig. 25 being a typical example. It consists, essentially, of an electro-magnet, in front of the poles of which is

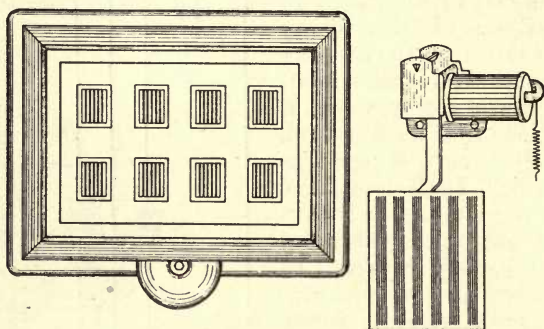


FIG. 25.

mounted a light armature, usually on knife edges. Attached to the armature is a stem which carries a square piece of metal, painted in alternate stripes of red or white, and black, or any other combination of colours which affords a sufficient contrast to readily catch the eye. The action is as follows. When current passes through the magnet coil the armature is attracted, and displaces the flag ; when the circuit is broken the flag falls back by gravity, and oscillates on its axis for an appreciable time before coming to rest, so that, when installed in series with a bell, the movement of the indicator flag persists after the

push has been released, and indicates the point of origin of the signal. This indicator is suitable for use in any situation where there is no vibration, as it will readily be seen that mechanical movement of any kind would set it in vibration irrespective of the current, and thus lead to confusion. Fig. 26 illustrates a double-pole pendulum indicator.

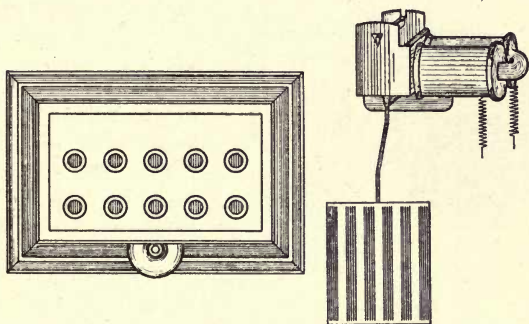


FIG. 26.

Combinations of each of the above-mentioned pendulum indicator movements, as they appear when mounted up in what are termed "Indicator Boards," with their flags in position behind the apertures in the screen plate, are shown alongside in Figs. 25 and 26.

(27) MANUALLY RESTORED INDICATORS

Wherever vibration is likely to be encountered the second class, or manually restored indicator, is used, Fig. 27. In this type of movement the signal consists of a displayed disc, which, when the indicator is normal, or inactive, remains hidden behind a screen,

pierced with holes, numbered or labelled to correspond with each indicator. The disc is attached to a pivoted arm, which engages with a detent controlled by the armature of the electro-magnet, such that when the latter is energized the detent releases the arm, and allows the disc to fall into full view

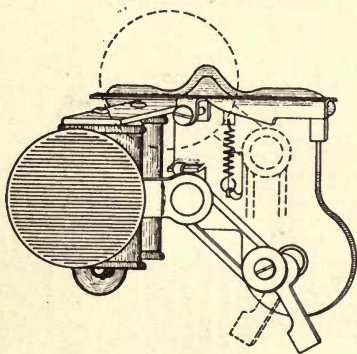


FIG. 27.

behind its aperture in the screen. This type of indicator is restored by pressing a knob at one end of the case. The knob forms part of a rod carrying a number of pins, which engage with an extension of the pivoted arm, and return it and the attached disc to the normal position.

The drop indicator is largely employed on ships, and similar places subject to vibration. For ship use extra precautions are necessary to prevent the ingress of dust, moisture and insects. To this end, the terminals of a ship's indicator board are usually mounted in a separate compartment at the top of the case, so that they can be wired without interfering with the interior of that portion which contains the indicator movements themselves.

(28) ELECTRICALLY RESTORED INDICATORS

Fig. 28 illustrates a typical Electrically Restored Indicator Movement, the curved armature being permanently magnetized and responding to currents

sent in opposite directions through the two independent windings of the coil.

(29) INDICATOR BOARD CIRCUITS

In large buildings with many rooms, some simple apparatus is necessary to indicate to the attendant in which room a call has originated. One method which at first suggests itself, necessitates a separate bell for each room, but, in such case, apart from the expense, great confusion would result should several calls be made simultaneously; and, in any event, the ear would have to be highly trained to distinguish which bell had rung. It is obvious, then, that such a system is impracticable save where two, or at most three, bells are concerned. The plan universally adopted in such cases is that of installing an indicator board, in conjunction with a single bell, which latter is merely an audible means of attracting attention, the indicator corresponding with the particular room or station calling being the real signal by which the attendant is guided.

Fig. 29 shows the connexions for such a system. The pushes, *C*, are fitted in the various rooms, and a separate wire run from each push to the indicator board *I*, a common wire being also connected to all the pushes, and to one terminal of battery *BA*. Another wire connects the remaining terminal of battery to bell *B*; the return path for the current being to a terminal provided on the indicator board.

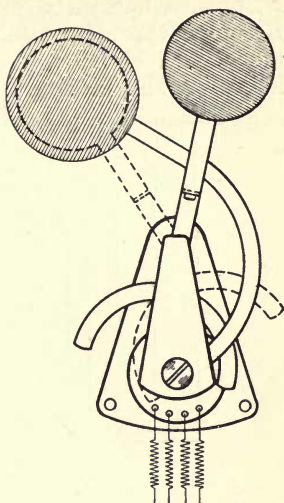


FIG. 28.

If, now, a button be pressed, current from battery *BA* flows through push, indicator and bell, back to the carbon of battery, operating the corresponding indicator, and ringing the bell. The latter will con-

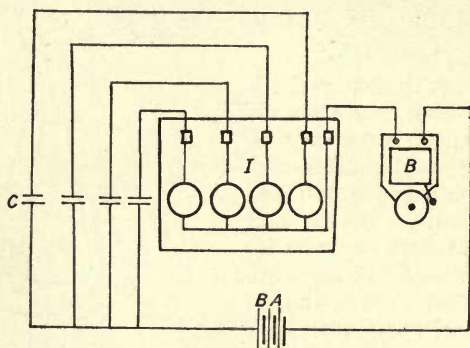


FIG. 29.

tinue to ring so long as the button is depressed, but the indicator may be arranged to signal either continuously or momentarily, this depending upon the type of movement fitted.

In cases where the attendant will not always be in the immediate neighbourhood of the board, it is necessary to fit a large loud-ringing bell, in which case a relay, *R*, Fig. 30, should replace the bell, and

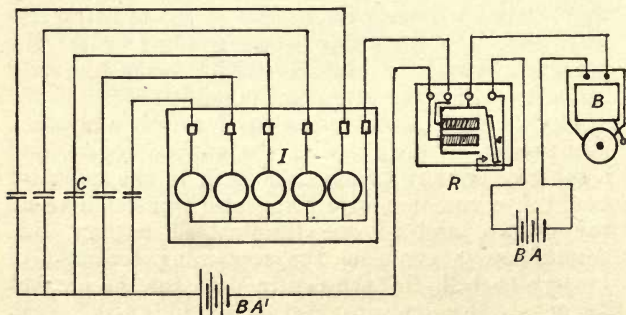


FIG. 30.

the latter be placed in a local circuit, as previously described. This arrangement will be much more effective, and practically any sized bell can be used.

Another system, shown in Fig. 31, employs two trembler bells, which can be fixed in two different

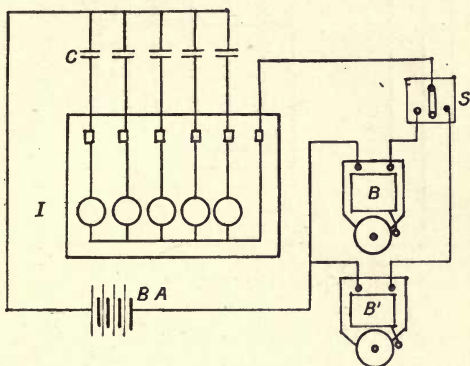


FIG. 31.

localities, as, e.g., where it is desired to call an attendant who may be either upstairs or down at the particular moment he is wanted. By simply moving the switch, *S*, to right or left, the attendant brings one or other of the bells into circuit with the indicator board.

In all the foregoing arrangements of indicator board the individual indicators are either of the *manually restored* or *pendulum* type. With the former, a permanent signal is given when once they are operated, and, with the latter, a vibratory signal, the vibration persisting long enough to enable the attendant to observe which particular indicator has been set in motion. In Fig. 32 is shown a system of *electrically restored* indicators, in which, by pressing push-button *P*, any displaced indicator may be restored to its normal condition. As in the case of the manually restored type, these indicators will

give a permanent signal until restored. The system has advantages over the manual in that less mechan-

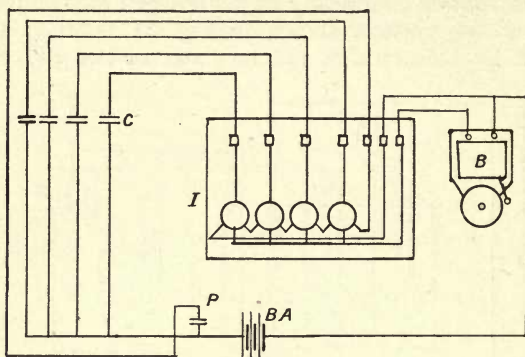


FIG. 32.

ism is required in the indicator board, and, consequently, wear and tear are proportionately reduced.

(30) TELL-TALE INDICATORS

An excellent system of Tell-tale indicators is shown in Fig. 33 wherein four separate indicator boards are installed ; one for each floor of an hotel or similar building, and a central master indicator board, fitted in the manager's or chief attendant's office. In the indicator boards fitted at the various floors, *I*, *I_A*, and *I_B*, manually restored indicator movements are used ; whereas the master board, *ER¹*, is equipped with electrically restored indicators. On reference to the diagram it will be observed that two wires run from the board on each floor to the central or master board, where they end in an indicator corresponding with that particular floor. It will also be seen that, should a call originate on any floor, the circuit from that particular push-button is completed through the indicator of the board corre-

sponding with that floor, master board indicator, bell *MB*, battery *BA*, and the common wire, back to push, thus operating the two indicators named,

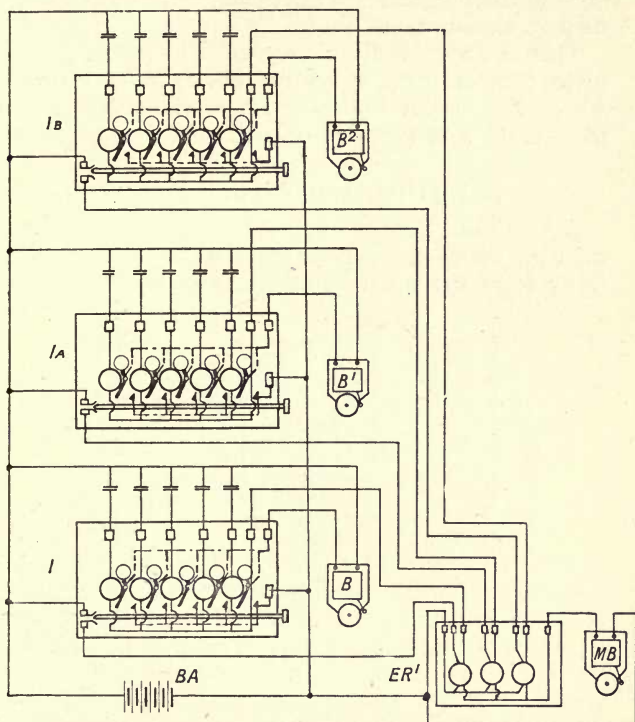


FIG. 33.

and ringing bell *MB*. One or other of the bells *B*, *B*¹, *B*², corresponding with the floor on which the button has been pressed, also rings, drawing its current through a local contact closed by the indicator arm. As both indicators remain permanently displayed, those in the boards *I*, *I*_A, *I*_B, have to be

manually restored, and it is possible, by fitting contacts to the restoring device, to simultaneously restore the master indicator on board ER^1 . Reference to the diagram will make this clear without any further explanation.

This is undoubtedly a very efficient system, complete control from a central office being secured, where the master indicator for each floor is under the eye of a responsible official.

(31) "CALL AND REPLY" SYSTEM.

A "Call and Reply" system is frequently required, as, e.g., where the person required is at an office away from the main building. Fig. 34 shows such

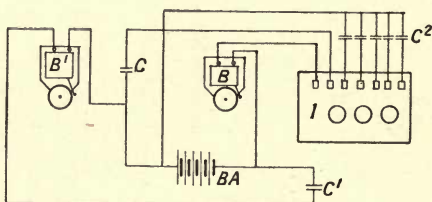


FIG. 34.

a system. To call the sub-office bell B^1 , contact C^1 is closed, and the call is answered by closing contact C , which actuates the indicator associated with this particular office on the indicator board I ; also ringing bell B . Contacts or pushes C^2 would, of course, be distributed throughout the main building in the usual way.

(32) LIFT INDICATORS

For attracting the attention of lift attendants it is customary to fit an indicator board, together with trembling bell, in the car, the movements being of a type previously mentioned, viz., manually restored.

Fig. 35 illustrates the connexions of one such system. As will be seen, it is necessary for the conductors to be left hanging in a loop, which compensates for the movements of the car up or down, and these con-

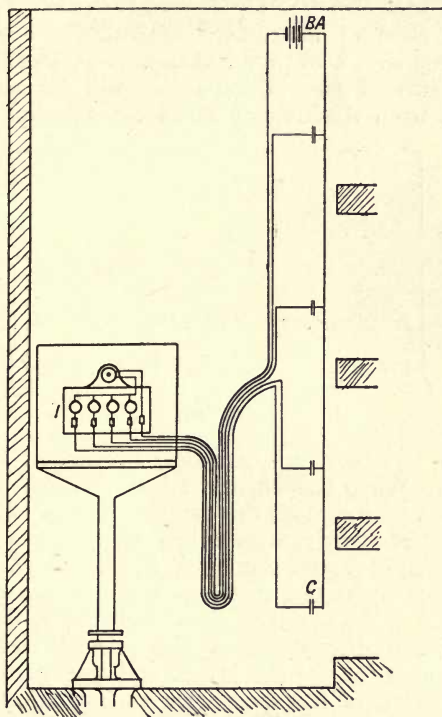


FIG. 35.

necting wires must be as flexible as possible, or break-ages will be frequent. The conductors should be of stranded copper wire, vulcanized india-rubber covered, taped, braided, and compounded, and should be bunched together and formed into a cable. Great care should be taken to allow plenty of spare length,

so that no undue strain is put upon the conductors. The connexions are sufficiently clear to be self-explanatory.

(33) DIRECT-WORKING TELEPHONES

This class of instrument embodies the simplest telephone circuit in practical use. Fig. 36 shows the connexions of two stations; it will be seen that current from the battery flows through both trans-

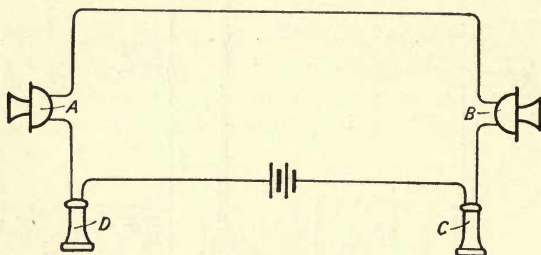


FIG. 36.

mitters and receivers in series, the action being as follows. When transmitter *A* is spoken into it either decreases or increases the total resistance of the circuit; consequently, more or less current flows through the transmitter and receivers, *B*, *C*, and *D*, and, as the effect upon the receiver is approximately proportional to the variation thus produced by the transmitter, the diaphragm of the former vibrates in unison with that of the latter, and thus gives a true reproduction of the speech waves impinging on the transmitter diaphragm at *A*.

This circuit is adapted to short lines; it is used very extensively for private houses, in connexion with existing electric bell systems, and, when properly made and installed, is capable of giving excellent results. This pattern of telephone has been largely developed by several manufacturers, and can be obtained in various finishes to harmonize with the

general decorations of the rooms in which it is used, thus being rather ornamental than otherwise. These telephones are not suitable for distances exceeding 100 to 150 yards; their simplest application is where they are used on existing electric bell circuits, and Fig. 37 is a diagram of such a circuit. It will be seen

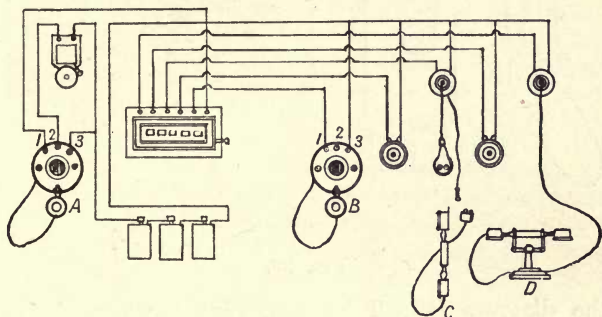


FIG. 37.

that the instrument *C* is simply connected across the two springs inside the push, the latter being manipulated, as usual, for ringing. There is one disadvantage accompanying this arrangement, viz., that the telephone, when once fitted, remains a fixture, as it would be very inconvenient to disconnect it every time it was required for use in another room. A better plan is to fit a special push, provided with two circular metal bushes, permanently connected to the two push-button springs. The flexible cord attached to the telephone ends in a two-pin plug as shown, which can be readily inserted into the two bushes; this enables one instrument to be moved from room to room, as required, with a minimum of trouble.¹

¹ In order that the instrument may not remain permanently in circuit when not in use, a speaking key is fitted in the handle, which, when pressure is released, opens the circuit through transmitter and receiver.

Fig. 38 shows how two rooms in a house can be enabled to communicate with a third, e.g. the kitchen, when no indicator board is fitted. On reference to

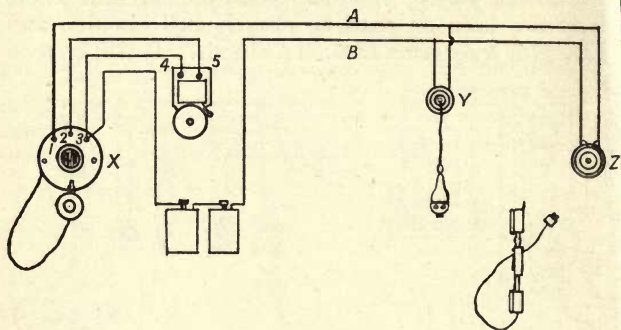


FIG. 38.

the diagram it will be seen that the attendant's telephone, X, has three terminals, instead of the usual pair corresponding with the lines; the third terminal is only used when it is necessary to cut the bell out of circuit when answering calls (this instrument being used only for answering, and not for originating calls). Fig. 39 shows the internal connexions. Although fitted with three terminals as required for answering purposes, the same type of instrument is also sometimes used at the calling stations, bridged across the push-button wires, in which case only terminals 1 and 3 are connected.

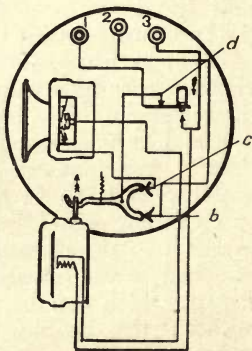


FIG. 39.

Two patterns of these instruments are available; in one the transmitter is fixed, and a separate receiver

employed, whilst the other has transmitter and receiver fitted in a handle common to both, this being the more convenient arrangement; the circuits, however, remain the same in both cases.

C, Fig. 37, shows such a combination, fitted with a two-pin plug so that it may be readily connected to one of the pushes. At *D*, Fig. 37, is illustrated a very convenient rest for this class of instrument, enabling it to be used as a desk or table telephone; it is also useful in case of illness for placing near the bedside. The only alterations necessary in the wiring are as follows. The bell, instead of being joined in series with the wire which is common to one side of all the pushes, is connected across terminals 2 and 3 of the attendant's telephone. The + pole of battery is also taken to No. 3 terminal, whilst No. 1 is joined to that terminal on the indicator board which is common to one side of all the indicators.

The circuits are as follows: suppose *B*, Fig. 37, wishes to call the attendant, he presses the ringing button of his instrument; a current then flows from + side of battery to one terminal of bell, through bell to No. 2 terminal of telephone; thence to contact *b* of switchhook (Fig. 39), top contact *d* of ringing key, which is in metallic connexion with same, and back to common terminal on indicator board, through the indicator corresponding with the station calling, to the push, and thus back to—terminal of battery. The attendant being summoned by the ringing of the bell, lifts his receiver from the hook, and, by so doing, disconnects the bell, and puts the telephone instrument in circuit; the caller also lifts off his receiver, and the two are in circuit with each other, and can converse.

The speaking circuits can now be traced. Starting from + pole of battery we first reach No. 3 terminal of instrument, passing thence through receiver and transmitter in series, to top contact, *c*, Fig. 39,

upon which the switch-hook bears when the receiver is removed as in speaking. From the switch-hook we pass to top contact *d* of push key, and out by way of No. 1 terminal to common wire on indicator board, through the indicator of the station calling, to the wire which is joined to No. 1 terminal of instrument *B*. Here the internal connexions will be the same as in the first or answering instrument, Fig. 39, the return wire leaving No. 3 terminal, which is joined to the common wire, and back to the — pole of battery, thus completing the speaking circuit of the two telephones through the latter.

If the hand combination type of instrument be used, the cycle of operations is exactly the same, except that, instead of the transmitter and receiver being brought into circuit when the latter is lifted from its hook, a key is provided in the handle of the combination, which, when depressed, completes the circuit for speaking.

If mutual calling facilities are required it will be necessary to provide each station with a bell, and instal a plug board in connexion with the attendant's telephone. For this purpose a special type of instrument is used, the bell, transmitter, receiver, push-key, switch-hook, etc., being all mounted upon a common base. Fig. 40 shows the arrangement of the internal circuits, the functioning of which will be obvious from the preceding explanation. The connexions are exactly as in Fig. 39, except that No. 2 terminal, instead of connecting with the bottom contact of switch-hook, is wired, through the bell, to the same point.

The plug board consists of a number of springs equivalent to the total number of indicators in use; each spring normally rests upon a fixed contact. The attendant's telephone is furnished with a plug for insertion in holes opposite the springs, the result being that it makes contact with the long spring, and lifts it out of engagement with the fixed contact

upon which it normally rests. This cuts the indicator of the calling station out of circuit.

Fig. 40 shows the method of wiring up three or

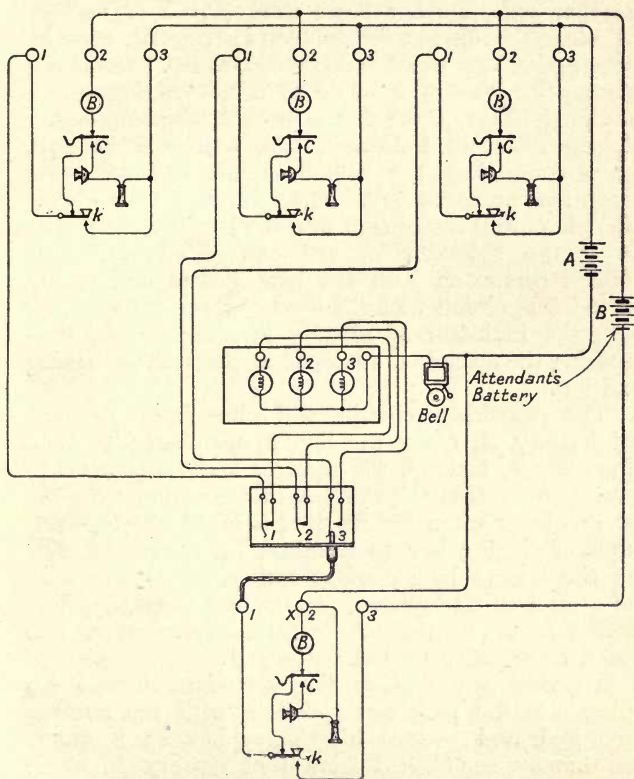


FIG. 40.

more stations. It will be seen that an additional common wire is necessary; this is to provide current from an extra battery for ringing purposes, when signalling from the attendant's telephone. The line

from No. 1 terminal on each of the remaining instruments, instead of going direct to the indicator board, passes through the spring contacts of the plug board.

The operation of the system is as follows. When a station calls, current flows from + pole of battery *A*, along the line to terminal 3 on instrument, through the ringing key, which is depressed, to No. 1 terminal; thence by way of the line to corresponding spring on plug board, through the back contact on which spring rests, to indicator, bell, and — of battery, thus completing the calling circuit and actuating both indicator and bell. The attendant then inserts the plug of his instrument into the jack corresponding with the indicator of the calling station. This makes connexion with the long spring, and causes it to break circuit with the fixed contact, thus cutting out the indicator as already mentioned, and connecting the attendant's telephone direct to the calling station.

The speaking circuit will be from + pole of battery *A*, along the line to terminal No. 3 on instrument, through the receiver and transmitter in series to contact *C* (which is in connexion with the switch-hook when the receiver is lifted off) top contact of ringing key to terminal 1; thence by way of the line to long contact spring, plug, terminal 1 of attendant's telephone, top contact of ringing key, switch-hook, contact *C*, transmitter, receiver, and back to negative pole of battery *A*.

To ring any station the attendant inserts his plug into the jack corresponding with the number required, and presses his ringing key *k*; a circuit is thereby established from + of battery *B*, along the common wire to terminal No. 2 on instrument, through bell, top contact of switch-hook and ringing key to No. 1 terminal; by way of the line to long spring of jack, plug, and No. 1 terminal of attendant's instrument, through his ringing key to terminal 3, and — of battery *B*. He thus calls the station re-

quired, and, should he inadvertently leave his plug in the jack when conversation is finished, it is still possible for a call to be received from that station as, although the indicator will be cut out of circuit, the incoming current will ring the attendant's bell.

It will be seen that the latter's telephone is not connected like the other instruments, the difference being that one side of the receiver, marked X, is taken to No. 2 terminal, instead of No. 3. It will be gathered from the diagrams that either hand combinations or fixed transmitter and receiver may be used. For internal connexions in the former case see Fig. 41.

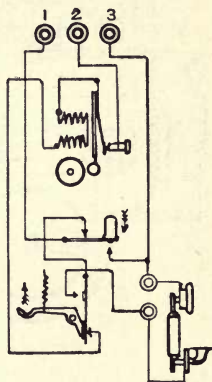


FIG. 41.

Fig. 42 shows how two stations are connected to ring and speak in both directions, separate batteries

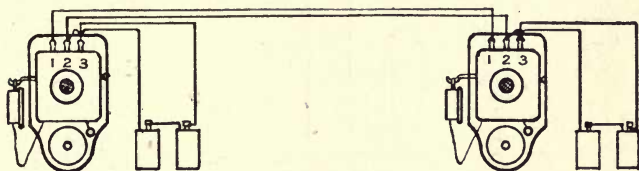


FIG. 42.

being used for calling and speaking at either station. For internal connexions of instruments, see Fig. 43.

Fig. 44 illustrates how two stations may ring and speak both ways, the battery being fixed at a common central point. Two different types of instrument are shown, *A* having a fixed transmitter and separate receiver and bell, whilst *B* is fitted with a hand-combination and bell mounted on common base.

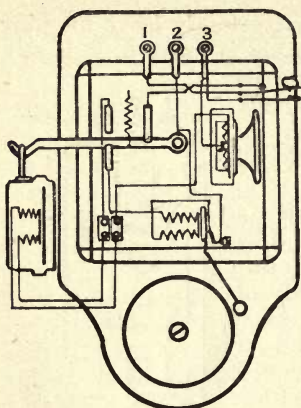


FIG. 43.

(For internal connexions of *A* see Fig. 39 and of *B*, Fig. 41.) They operate as follows. If *A* station wishes to call *B*, he depresses his ringing key; the path of the ringing current from + of battery is then by way of No. 3 terminal of *A* instrument, ringing key, No. 1 terminal, line *C*, No. 1 terminal of *B* instrument, bell, No. 2 terminal, *D* line, and back to - pole of No. 1 battery. This rings the

bell at *B* station. When the two are through speaking, the circuit can be traced from + of No. 1 battery,

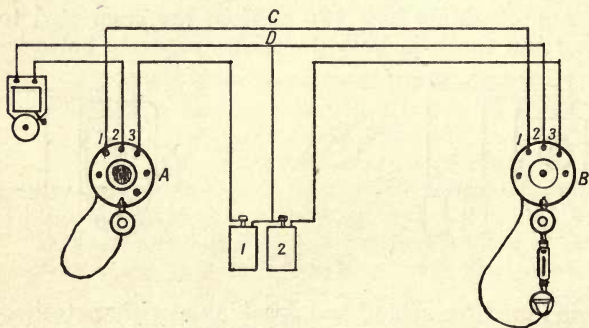


FIG. 44.

No. 3 terminal, transmitter, receiver, No. 1 terminal, *C* line, No. 1 terminal of *B* station, transmitter, receiver, No. 3 terminal, and to - pole of battery No. 2. It will thus be seen that both cells are used

for speaking and one only for ringing, the battery being increased, if necessary, to suit conditions.

Fig. 45 shows how two stations are joined up to enable them to ring and speak both ways, separate bells and batteries being employed. If *C* wishes to call *D* he depresses his ringing key. Current then flows from + pole of battery 1, along the *B* line to bell at *D* station, thence through the instrument to *A* line, and back through the ringing key

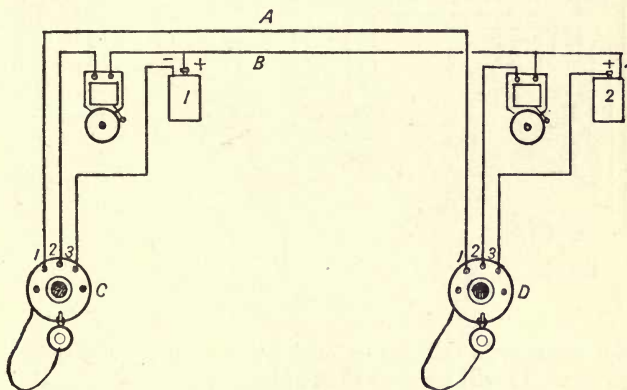


FIG. 45.

at *C* station to - pole of battery No. 1. The bell at *D* station is thus set ringing. The speaking circuit is as follows. Starting from + pole of No. 2 battery at *D* station, No. 3 terminal, transmitter, receiver, No. 1 terminal, *A* line, No. 1 terminal at *C* station, transmitter, receiver, No. 3 terminal, - pole of No. 1 battery, *B* line, - terminal of No. 2 battery, which completes the circuit.

Care must be exercised when installing this circuit to see that the + pole of battery is connected to the *B* line at station *C*, and the negative pole of No. 2 battery to the *B* line at station *D*; otherwise the

two batteries will oppose one another, and the telephones will fail to work.

In offices, works, etc., it is sometimes desirable for the manager or departmental head to be able to communicate with a number of subordinates, they also being able to call him, but not one another. Such an arrangement is depicted in Fig. 46; *A* being

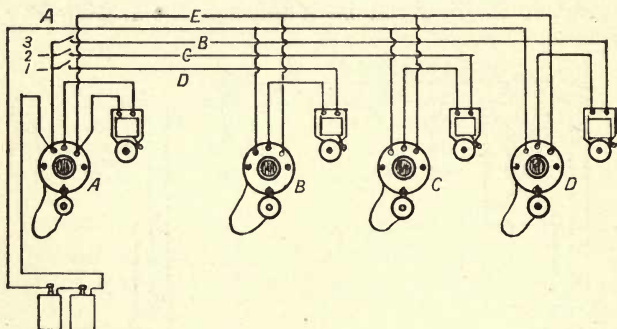


FIG. 46.

the manager's telephone, and *B*, *C*, and *D*, the sub-offices. It will be seen that only one battery is used, both for ringing and speaking. A separate line is run to each station, one terminal of the battery being common to all the sub-offices, where it ends in No. 1 terminal on each instrument. The manager has a board, fitted with as many pushes as there are stations, and numbered to correspond. One wire is common to all the push-buttons, and is connected to No. 1 terminal of the manager's instrument. The mode of operating is as follows. If station *A* wishes to call *B*, he depresses push No. 1; current then flows from + pole of battery, along the *A* line, No. 1 terminal of *B*, top contact of ringing key, No. 2 terminal, bell at *B*, line *D*, push, No. 1 terminal of *A*, and so back to the negative pole of battery, com-

pleting the circuit and ringing bell at *B*. When both take their receivers from the hooks the path of the speaking current is as follows. From + of battery, *A* line, No. 1 terminal at *B*, transmitter, receiver, No. 3 terminal, line *E*, No. 3 terminal at *A*, transmitter, receiver, No. 1 terminal, and thence to - pole of battery. For internal connexions of instruments see Fig. 39.

In Fig. 47 we have an arrangement of three sta-

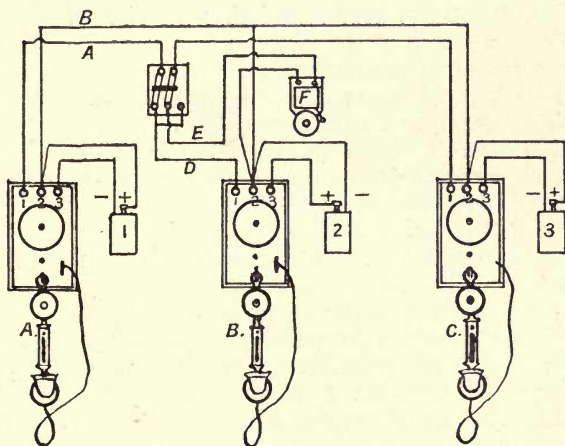


FIG. 47.

tions with the following facilities. By manipulating a two-way switch, *B*, i.e. the centre station, can ring *A* without disturbing *C*, or ring *C* without attracting the attention of *A*. Conversely, stations *A* or *C* can call *B* independently, and irrespective of the position of the switch at *B* station. For example, if the latter wishes to call *A*, he throws the switch over to the left, and presses his ringing key; current then flows from + pole of No. 2 battery to No. 3 terminal, ringing key, terminal No. 1, left side of 2-

way switch, line *A*, No. 1 terminal of *A*, ringing key, switch-hook, bell, No. 2 terminal, line *B*, and thus to — terminal of battery 2. When both lift off their receivers the speaking circuit is established as follows. From + pole of No. 2 battery to No. 3 terminal, transmitter, receiver, No. 1 terminal, line *D*, left side of switch, *A* line, No. 1 terminal at *A*, transmitter, receiver, No. 3 terminal, — pole of No. 1 battery, through No. 1 battery, No. 2 terminal, line *B*, No. 2 terminal at *B*, to the — pole of No. 2 battery, thus completing the circuit.

From a study of the diagram it will be seen that if the batteries are not connected as shown, speech will be impossible, as the two batteries will oppose each other, and no current will flow.

If station *B* wishes to call *C* the same procedure is gone through except that the switch is thrown to the right, instead of to the left as previously. An extra bell is provided at *B* to enable either station *A* or *C* to call, no matter in which position central has left his switch.

If we assume the latter to be over to the right, and that *A* wishes to call, he depresses his ringing key; a current flows from + pole of No. 1 battery along the *B* line, No. 2 terminal of *B*, extra bell *F*, middle contact of switch, *A* line, No. 1 terminal of *A*, ringing key, No. 3 terminal, and thus back to — pole of battery No. 1. (For internal connexions see Fig. 41.)

(34) BATTERY CALL TELEPHONES WITH INDUCTION COIL

The telephones described hitherto are limited to short distance duty, owing to the fact that when the line has considerable resistance the current variations caused in the circuit by the transmitter vibrations become too small to have any useful effect. For example, consider a circuit having a

resistance of, say, 100 ohms. If it be possible for the transmitter to vary the total resistance of the circuit by five ohms, the total variation produced in the circuit will be only 5 per cent., and thus its power of setting up pulsations in the line will be correspondingly small. To obtain a greater variation for long distance work, the circuit must be so arranged that the change in the transmitter resistance will bear a much higher ratio to the total resistance of the circuit. This was accomplished by Edison in 1878 with the aid of the induction coil, or step-up transformer.

(35) INDUCTION COIL

The latter has a core of thin charcoal iron wire, fitted with two wooden cheeks or flanges. Upon this core, which is first carefully insulated, are wound two or three layers of No. 22 S.W.G. copper wire (usually from 200 to 400 turns) to form the "primary." This winding is then carefully insulated with two layers of waxed paper, and over it again is wound a second series of layers, termed the "secondary," and which usually consist of from 3,000 to 4,000 turns of much finer wire, about 36 S.W.G.

The action of the telephone induction coil is very similar to that of the step-up power transformer, in that the primary circuit is energized by a large current at low voltage, and induces in the secondary winding a small current at high voltage. It will be seen that the higher voltage thus induced in the secondary will be better able to overcome the resistance of a long line. Another advantage is that the transmitter is placed in a circuit of low resistance, usually about 1 ohm, so that a slight variation in the transmitter resistance will cause a relatively large variation of the current in such a circuit. A third advantage is that the transmitter is eliminated from the line circuit, where its presence would be extremely

objectionable owing to variable resistance. The fourth advantage is that in the secondary winding the current is alternating in character.

(36) FUNCTION OF INDUCTION COIL

Let us now consider the function of the induction coil in a telephone circuit. When the resistance of the transmitter is varied, more or less current will flow through the primary winding, but this current will always be in the same direction; it will simplify matters to consider the transmitter as a valve which injects spurts of current into the primary winding. The induced current in the secondary will be alternating in character owing to the fact that when the primary current is increasing that in the secondary will flow in an opposite direction, whereas, when the current in the primary is decreasing the secondary induced current will be in the same direction as the primary current.

Fig. 48 shows the connexions of two battery telephones including induction coils. The circuits can be traced as follows. When No. 1 wishes to communicate with No. 2, he presses the ringing key, which results in joining the line terminal of his instrument to the positive terminal of the ringing battery; a current then flows along the line, through the back contact of the ringing key of No. 2 instrument, and its bell, to the top contact of the speaking key; thence to the *ZE* terminal, and back through the earth (or second line if the circuit be metallic) to the other pole of the battery. Upon receiving a ring, No. 2 takes up his telephone, and, by pressing the speaking key in the handle, disconnects it from the top contact, and connects it, instead, to the two bottom contacts. A circuit can then be traced from the *MC* terminal, through the primary winding of the induction coil, transmitter, and speaking key,

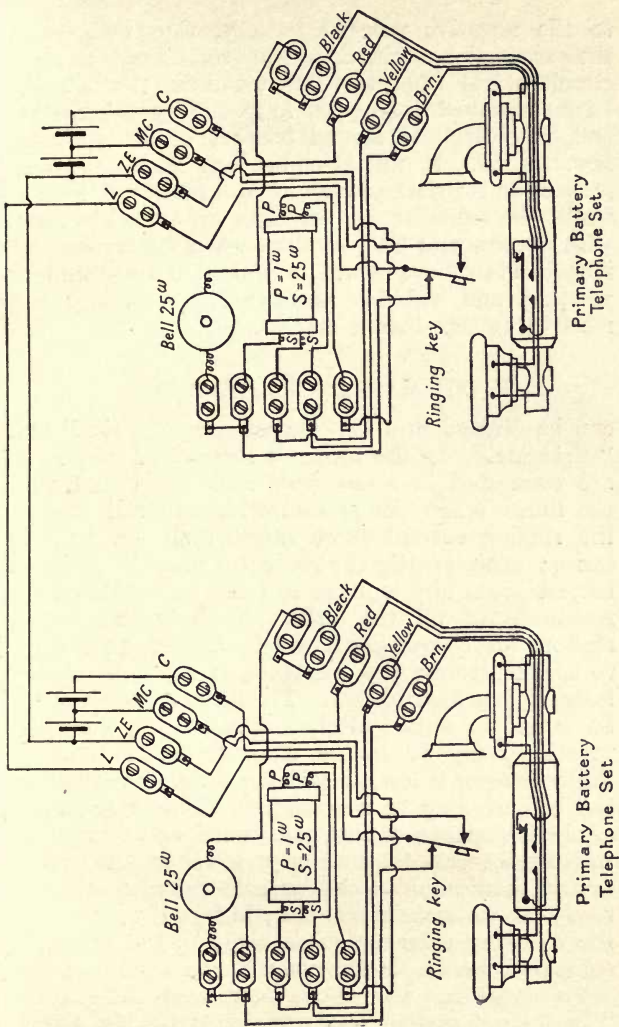


Fig. 48.

to the negative pole of battery, thus completing the transmitter circuit. The secondary or line circuit starts from the line terminal, through the back contact of ringing key to secondary of induction coil, receiver, and second contact of the speaking key, to *ZE*. It will thus be seen that the transmitter and primary circuit is completed locally, whilst the secondary and receiver are joined in series with the line and *ZE*; so that, when the transmitter is spoken into, current will be induced in the secondary winding, and will flow through the secondary and receiver at the distant station.

(37) MAGNETO TELEPHONES

can be divided into two classes, viz., "Series," and "Bridging." In the former a number of telephones are connected in series with each other and with the line. When one station wishes to call another the ringing current flows through all the bells in series; consequently the generator must be designed to produce a high voltage in order to overcome the resistance of all the bells. Similarly, when two stations are conversing it will be necessary for them to speak through the resistance of the bells of any intermediate instruments. The latter must therefore be wound to a moderately low resistance, the usual practice being 80 to 120 ohms for each bell. As the resistance is low, so will the number of turns in the bell winding be a minimum. This is essential, as the impedance of any coil wound on an iron core will reduce speech efficiency to a much greater extent than would a similar coil wound non-inductively to the same resistance; in fact it may reduce the speaking efficiency from eight to ten times, as compared with a similar non-inductive winding.

To overcome the above-mentioned defects the "Bridging" system was introduced by Mr. Carty, of America. Under this system all the telephones

are joined in parallel across the two line wires. This necessitates winding the ringers to a very high resistance (from 1,000 to 2,500 ohms) the average being 1,600 ohms. Owing to the high resistance of the bells the speech currents are not appreciably affected by their presence in the circuit, and much better speech transmission is secured than by the series arrangement. In this type of instrument it is necessary for the generator to be more powerful since

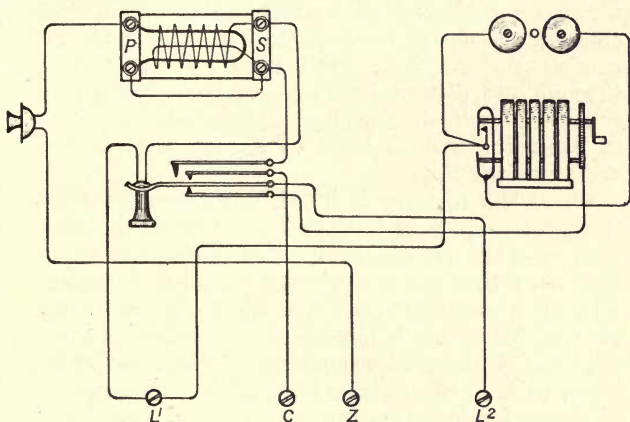


FIG. 49.

it has to ring a number of bells in parallel. Such generators usually have five magnets, and their armatures are wound to a low resistance, ranging from 50 to 100 ohms. A good five-magnet generator should yield 100 volts on open circuit and the P.D. should not fall below 50 volts when ringing ten 1,000 ohm bells in parallel, assuming no line resistance.

Fig. 49 shows the internal connexions of a typical magneto telephone, the same being equally applicable either to a series or a bridging instrument. The only modification necessary is in the type of generator

and ringer, as already described. The operation of the circuit is as follows. First consider the receiver in position on the hook (its normal position when not in use). The lines are connected to the terminals L^1 and L^2 , and a circuit can be traced from L^1 to back contact on generator and bell, through generator to bottom contact of switch-hook, and thence to L^2 .

When calling another station the handle of the generator is turned; the shaft is automatically thrust forward, and allows the two springs to make contact, thereby short-circuiting the bell. The ringing current then flows from generator to L^1 , through the distant instruments, back along line 2 to switch-hook, through its bottom contact, to frame of generator and so back to the other end of the armature winding.

When the receiver is lifted, a current flows from the positive pole of battery to the two top contact springs of the switch-hook, which are then connected together; through the primary winding of induction coil to transmitter, and thence back to negative pole of battery. A circuit is also completed from L^1 , through receiver, secondary winding, and switch-hook, to L^2 . It will thus be seen that the resistance of the generator armature is cut out of circuit when not in use, so that any received ringing current has simply to overcome the resistance of the bell; a very desirable feature. Also, when ringing out to line, the armature is automatically brought into circuit, and the bell at the calling station short-circuited; this is likewise an advantage, as it means one bell less to ring, a consideration when the number of stations connected is considerable, and the generator fully loaded in consequence.

There are many variations of the circuits used in magneto telephones, but they are all arranged to fulfil the following conditions. That when the receiver is in position on the switch-hook the ringer

only is in circuit, ready to receive a call. It must also be so arranged that under the same conditions a ringing current can be sent out to the lines and the bell may or may not be cut out of circuit when the generator handle is turned; so that, when the switch-hook is down the signalling arrangements are in circuit. When the receiver is lifted the signalling arrangements are cut out and the speaking circuits brought in, the battery circuit being closed and thus energizing the transmitter; whilst the secondary circuit is completed through receiver, induction coil secondary, and line.

If the foregoing principles are thoroughly grasped, no difficulty should be experienced in dealing with any class of magneto telephone.

(38) INTERCOMMUNICATION TELEPHONES

This system is for telephonic communication between various departments and rooms in warehouses, offices, and large establishments, where the calls are so infrequent that the expense of a central switchboard and operator is not justified. The maximum number of sub-stations permissible on a system of this kind is reached when, say, 20 lines are interconnected, and it then becomes preferable to adopt the central switchboard and operator. The limit will be more apparent when it is realized that the number of connexions for a five-line installation is 25; for a ten-line, 100; and for a twenty-line, 400; these figures representing line connexions to the instruments, and exclusive of those to junction boxes, etc. It may also be pointed out that the above figures represent single lines only between stations; consequently, if metallic circuits be adopted the above numbers will be doubled. It is undoubtedly preferable to employ metallic circuits wherever the extra cost is permissible, as by this means induction or cross-talk between the various circuits may be

reduced to a minimum, in that the wires may be twisted together throughout the length of the cable. An intercommunication system, however, will give excellent service whichever arrangement of line connexions is adopted, if properly installed, and embodying suitable apparatus. It is a mistaken policy to instal cheap and nasty apparatus; trouble will also be experienced if the wiring be improperly executed or the wrong material used. The following instructions are drawn up with a view to enabling the installer to obtain the maximum efficiency from any maker's apparatus, and may therefore be taken as referring in general to any intercommunication system.

It should, however, be pointed out that these instructions refer particularly to metallic circuit systems, although they are also applicable, with some reservations, to those installations which embody single line circuits with common or earth return.

(39) INSTRUMENT LOCATION

In considering the lay-out of the system, the first thing to be considered is the disposition of the telephones. Generally this point has been settled prior to the issuing of the specifications for tendering purposes. Should any alterations be found necessary in the original arrangement these should be definitely settled, and the locations shown as accurately as possible on the plans of the rooms or offices, otherwise waste of materials and time will result.

The position of each station being settled, the convenience of the user is the next consideration, and the most suitable run for the cable must be borne in mind. In the case of wall sets a position can readily be found which will allow the best disposition of the cable, and, in the case of desk sets an extra length of cable must be allowed to reach from the

wall to the instrument. If the system adopted be such that separate, or local, batteries are used, a suitable place for these can easily be decided upon, and they should preferably be mounted in a box, with hinged front, placed in some handy cupboard or corner where they are readily accessible for inspection. Triple leads are taken from the batteries to the telephones, and joined to the terminals marked for their reception. If, however, a system employing a central battery for speaking and ringing be adopted, a point near the centre of the installation should be chosen for the batteries, and pairs of wires run from them either to a main cable junction box, or to the nearest station junction box, and thence distributed to the various stations.

In the case of the speaking battery the leads will first be run to retardation coils, one, differentially wound, for each line, and a pair of wires from each retardation coil to each line connected. The function of the retardation coils in the central battery system is to prevent cross talk from one line to another through the battery.

When the telephone and battery locations have been decided upon it is a comparatively simple matter to settle the positions of junction boxes. These, as a rule, are of stained and varnished hard-wood, with holes in the back for fixing screws. They are provided with screw-on covers, slotted at both ends and at the centre, for cable entrance, Fig. 50. The terminal connexions are preferably brass plates, each fitted with three terminal screws; the plates are secured to a hard-wood strip, mounted the length of back of box, and plainly numbered. The boxes should be so fixed that a straight course is obtained for the cable, and waste of the latter by tortuous turns and twists avoided. Obviously the junction box feeding any telephone need not necessarily be mounted close to the instrument; its position will be decided by the run of the main cable.

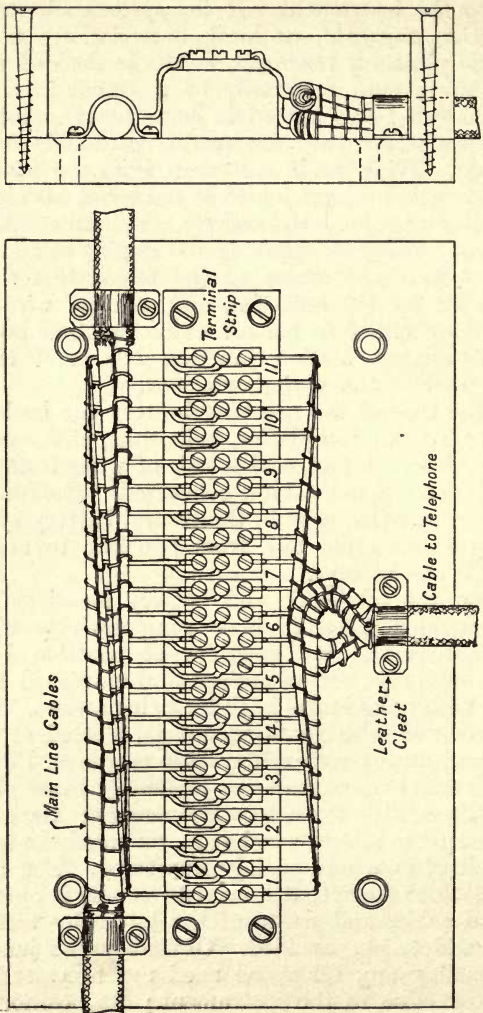


FIG. 50.

In Figs. 51 to 54 are shown plans illustrating the layout for systems ranging from 5 to 20 lines, with various connexions to junction boxes for particular

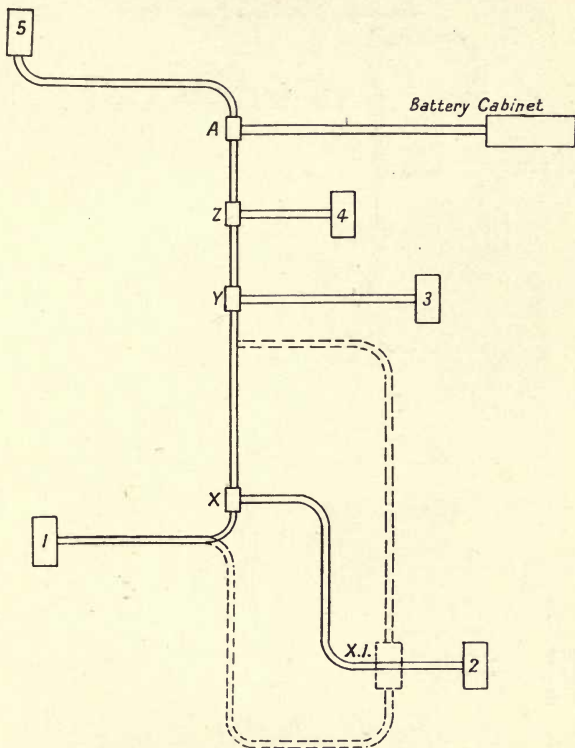


FIG. 51.

circumstances which may arise. Fig. 51 shows a layout for a simple system embodying five stations, Nos. 1-5. It will be noted that the main cable runs from stations 1 to 5, with intermediate junction boxes feeding stations 2, 3, and 4. The dotted lines represent an alternative route for the cable,

bringing box $\times$ nearer station 2. Fig. 52 illustrates a layout with branch lines. Fig. 53 depicts

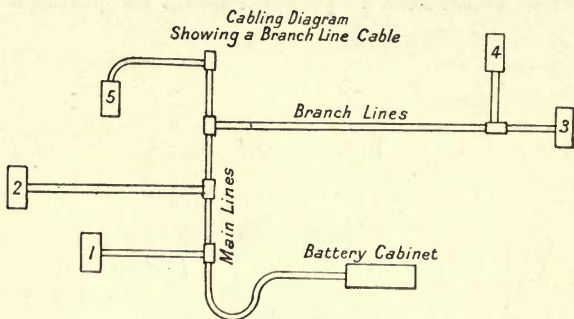


FIG. 52.

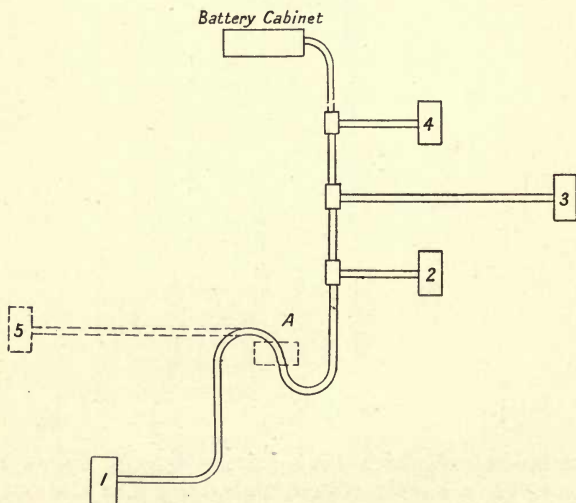


FIG. 53.

a case in which slack cable has been left for future junction box extension; and Fig. 54, an arrange-

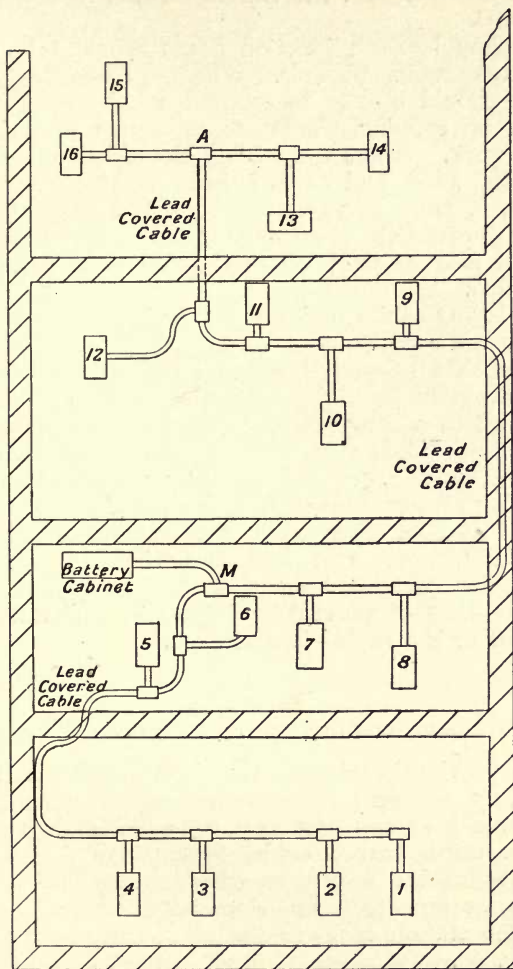


FIG. 54.

ment of cabling for the various floors of a warehouse or hotel.

Cabling between junction boxes should take the shortest route possible. Where permissible the cable should be run in grooved wood casing with screw on capping, similar to that used in electric light work. Where the cabling has to be concealed, let into walls, and carried under floors, or out of doors, it must be protected by a lead covering or other protective sheathing. Lead covered cable should also be used where the run is in a damp situation.

In laying cables under floors, or between walls, a heavy iron wire, No. 8 or No. 10 S.W.G., with hooked end, should be passed through the hole bored to accommodate the cable, and under the floor or along the wall to a corresponding hole bored for its exit. The cable should then be firmly secured to one end of this draw wire, and carefully pulled through, avoiding all strain upon the conductors. Great care should also be exercised in the bending of cables, especially those with lead sheathing, as, should this outer covering become cracked or broken, its object—that of preventing ingress of moisture to interior of the cable—is destroyed.

(40) CABLE-CONNECTING IN JUNCTION BOXES

As previously stated, the junction boxes are generally arranged to accommodate three cables; e.g., one incoming and one out-going main cable and a third, branch cable, feeding the telephone with which the box is associated. The two main cables are brought to one side of the terminal strip, and the station cable to the other side, as shown in Fig. 50.

It will be well to digress at this stage in order to consider the type of cable used, and its construction.

(41) CABLES

A typical specification of a telephone cable used in open indoor positions is as follows :

For an 11-pair cable the conductors, of 22 S.W.G. tinned copper wire, are each covered with two laps of silk, laid on in opposite directions ; and over this with one lapping of one of twelve variously coloured cottons, as in the table below. The insulated conductors are then run through a tank of hot molten beeswax, any superfluous wax being removed as they emerge from the tank. Eleven of the variously coloured wires are then each twisted up with the twelfth (white) wire, and the resulting eleven pairs then stranded together to form a core. Over this multiple core are lapped in order, fine soft cotton, strong fibre paper, tin-foil, and paper ; the whole being finally protected by two braidings of fine and coarse cotton respectively. The outer surface is coated with asbestos paint to render the cable flame-proof, and to assist in preventing ingress of moisture.

One scheme of colours for the twelve cottons is as follows :—

	Twisted with White (12)	
1. Blue		
2. Orange	”	—
3. Green	”	”
4. Brown	”	”
5. Slate	”	”
6. Blue and White	”	”
7. Blue and Orange	”	”
8. Blue and Green	”	”
9. Blue and Brown	”	”
10. Blue and Slate	”	”
11. Orange and White	”	”

The constructional difference between this cable and the concealed or lead-covered type, is only in the outer coverings. In the case of a lead-covered cable each pair of conductors is covered as before, and the whole stranded together. Over this core

is then lapped a stout linen tape, which forms a basis for the lead sheathing.

The above-mentioned types of cable are the very best and most expensive; three other cheaper specifications are therefore included, from which good average results may be obtained.

(1) Each conductor No. 22 S.W.G. tinned copper wire, india-rubber and double cotton covered, and thoroughly paraffin-waxed. All the pairs twisted together, and collectively stranded into a cable, braided over all with grey or other coloured cotton, and well paraffined. One wire of each pair to have a distinctive coloured cotton lapping, and its companion wire white, as previously.

(2) As in (1) but with two additional conductors (for the battery) of 3/22. Finished as above.

(3) Flexible cable for connecting desk telephones, may consist of the following: Each conductor, 24 strands of No. 38 S.W.G. plain copper wire covered respectively with white and distinctive coloured cottons. Each separate pair twisted, and the whole stranded together. The core braided with green cotton, and finished with an outer braiding of green silk.

(42) METHOD OF MEASURING OFF CABLE

The cable is left uncut, and the outer covering removed from a space opposite the terminal strip. If the distance between cable and terminals amounts to, say, 4 in. (allowing 1 in. for twisting around separate terminals, also spare wire in case of breakage), then the total length of cable to be opened up is $6\frac{17}{32}'' + (4'' \times 2) = 14\frac{17}{32}''$ (see Fig. 55); where $6\frac{17}{32}''$ is the length of the laced portion, and 4'', that between the body of the cable and the terminals. The open cable is laced with the two ends of the covered portions, $6\frac{17}{32}''$ apart, each colour being picked out and turned down over its

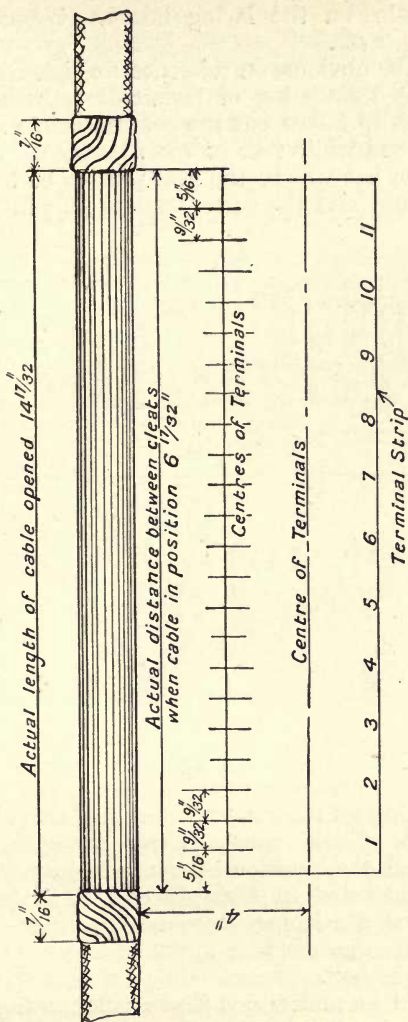


FIG. 55.

correct pin on the lacing board, *after which the loop can be cut.*

It will be obvious, on reference to Figs. 50 and 55, where the numbering of terminals is from left to right, that to follow out the colour scheme as given, the blue and white pair of wires in the cable entering on the left will be the first pair to be taken out of the cable, and the corresponding pair taken from

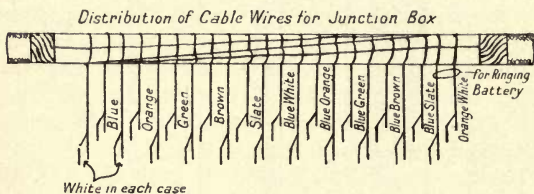


FIG. 56.

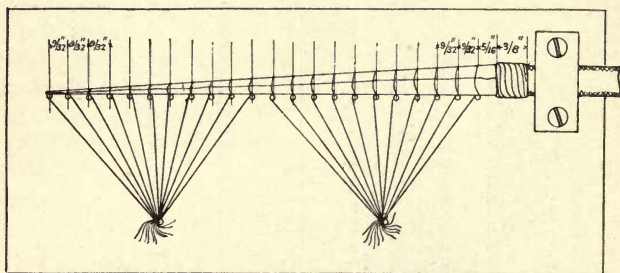


FIG. 57.

that entering on the right will be the last pair to be taken out of *that* cable. These arrangements of cabling and the positions the conductors will take up are illustrated in Figs. 56 and 57; the latter also illustrates a lacing board with a series of nails, spaced the same distance apart as the terminals in the junction box.

It should be understood that similar arrangements will suffice for forming out larger or smaller cables.

The method of terminating a station cable in junction boxes is very similar, except that the formation takes the shape of a "T" (see Fig. 50). When the cables are finally placed in position in the boxes, previous to connecting to terminals, they should be cleated in position by a strip of raw hide as shown.

(43) CABLING WALL TELEPHONES

In order to lead a cable into the interior of a telephone instrument, the latter is usually drilled both top and bottom, so that the cable may be brought

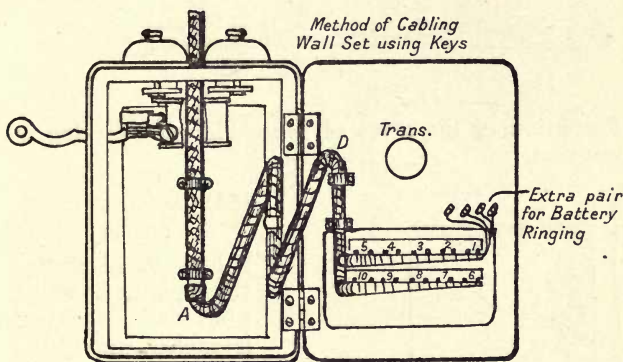
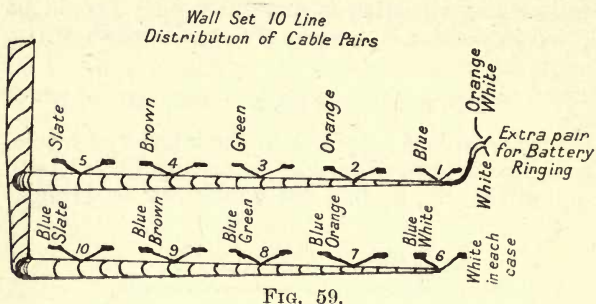


FIG. 58.

in as is most convenient, and plugs are provided in both of these openings to exclude dust. The plug will be left permanently in that opening through which the cable does not enter.

Fig. 58 shows a method of terminating a cable on the keys in a wall set when the cable enters from above. In every case the latter should be cleated to the back of the instrument. From A, the cable passes through a double hinge formation to D, the object of the hinge being to allow the door to be opened without disturbing the permanent wiring on

the keys. On the door itself the cable is formed out into two arms, which are spaced out slightly below the level of the rows of keys. Fig. 59 shows the



formation of the arms of the cable before fixing in position.

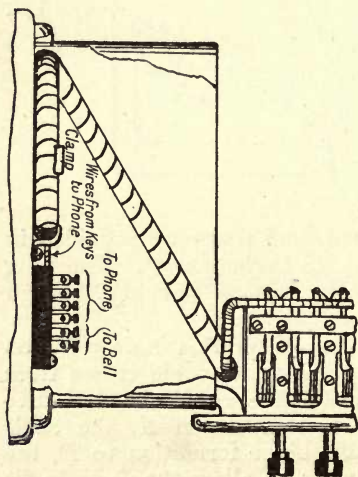


FIG. 60.

(44) CABLING DESK BOXES

Fig. 60 illustrates the manner in which a ten-station desk box is cabled, the cable being arranged in arms feeding to the two rows of keys, as in the wall sets. All the miscellaneous wires in the key boxes are arranged to terminate on a row of six terminals in base of box, four for connexion to the telephone, and two to the bell.

the "butt" of the cable being about 1" from nail *A2* when the form is under construction. Dotted lines *A1*, *B1*, *H*, and *I*, show the form for a twenty-line box. When carrying the telephone connexions into the cable form the six-terminal block previously mentioned in connexion with desk sets, should be removed and screwed in position as shown in Fig. 62. The wires leading from this rack can then be laced in with the main cable.

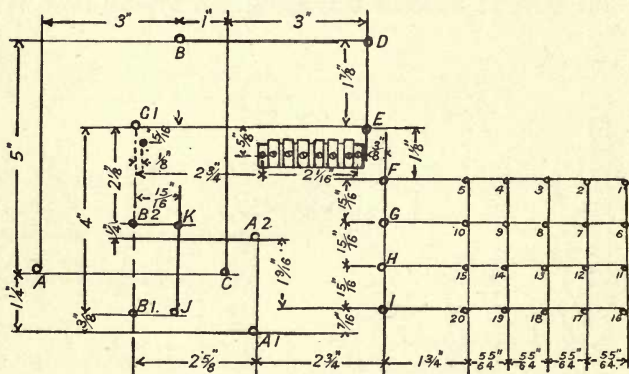


FIG. 62.

Whilst forming is in progress the cable should be firmly held by means of a cleat, applied close to the "butt." Forming having been completed the wires should next be neatly laced together with waxed sail-maker's thread. The completed cable is then detached from the forming board, and immersed in a tank of hot molten beeswax compound, in which it is allowed to remain until no more air bubbles are seen to rise. On cooling it should be well varnished with shellac, and finally bound with good moisture-proof tape from the "butt" to that point on the

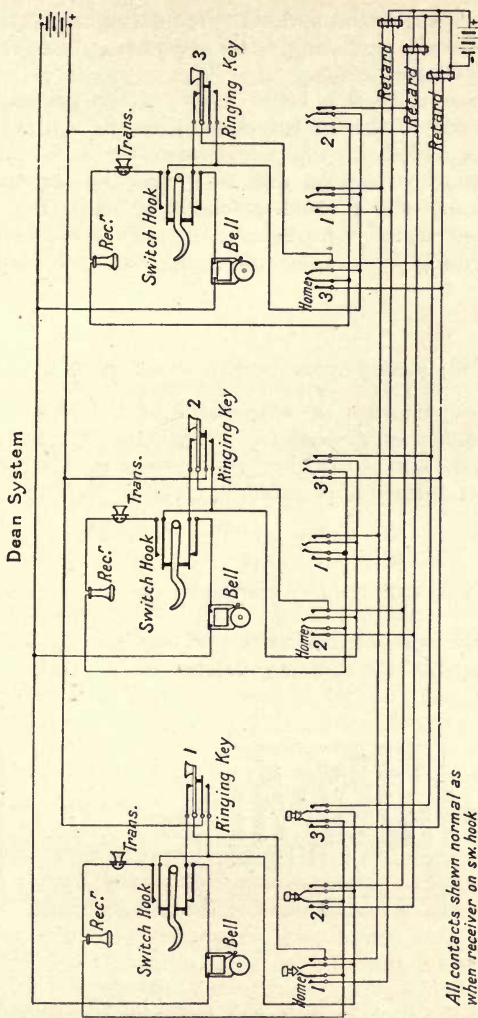


FIG. 63.

All contacts shewn normal as when receiver on sw. hook

arms at which the several wires diverge. The cable is now ready for fitting; the arms being bent at right angles where necessary.

To facilitate this latter stage of the process it is preferable to thread the cable through the entrance hole provided in the woodwork, prior to forming the ends; otherwise difficulty may be experienced in passing the formed-out ends through the small aperture usually provided. At the completion of the forming process the slack cable can then be pulled back.

(46) CONNEXIONS OF THE DEAN SYSTEM

A key diagram of connexions of the Dean Inter-communication system, as used practically throughout America, and to which the foregoing instructions are particularly applicable, is given in Fig. 63.

(47) CONNECTING CABLE TO SPEAKING BATTERY

Where one central battery is employed, as in the most up-to-date systems, it is necessary to introduce

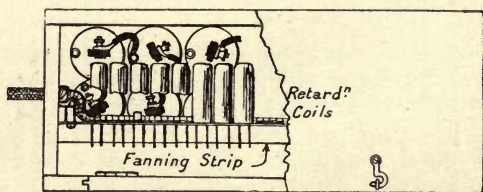


FIG. 64.

a retardation coil into the speaking battery leads for each station. These coils are usually mounted

together, on an iron plate, located in the cabinet which also accommodates the battery, the four ends of the windings of each coil terminating in soldering tags or terminals. One pair of tags belonging to each coil is wired in common, to the battery; the remaining tags being connected to the corresponding pairs of line wires from the various stations. The arrangement of the battery cabinet is shown in Fig. 64, which also illustrates one method of leading in the cable.

(48) CONNECTING RINGING BATTERY

The ringing battery should be located in the same cabinet as that used for speaking (Fig. 64). In the case of an eleven-pair cable the wires for connexion to this latter battery would be the eleventh pair in the colour code, viz., orange-white, twisted with a white, and they should terminate on the tags marked "Ringing." In connecting the ringing battery leads it is important to note that the correct polarity is assured. To this end the orange-white wire should be connected to the positive terminal, to which is also joined the positive pole, or carbon electrode of the ringing battery. Similarly the white wire should be connected to the negative terminal, together with the zinc connexion of the battery.

These remarks apply also to the speaking battery; e.g., all the tags corresponding with similar ends of the windings of the retardation coils (the other ends of which have coloured wires attached) should be connected together, and to terminal marked +; thence to the carbon terminal of the speaking battery. The remaining coil tags (companions of those which have white wires attached) should also be joined

together, connected to the negative terminal, and thence to the zinc of battery.

The ringing battery should consist of 8 dry cells, yielding about 12 volts; and the speaking battery of 6 cells, yielding approximately 9 volts. The correct method of wiring the battery cabinet is shown in Fig. 65.

When the system is of the "local battery" order, i.e., where separate speaking batteries are used for each station, and a common ringing battery, the

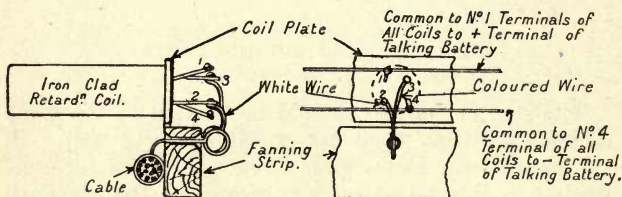


FIG. 65.

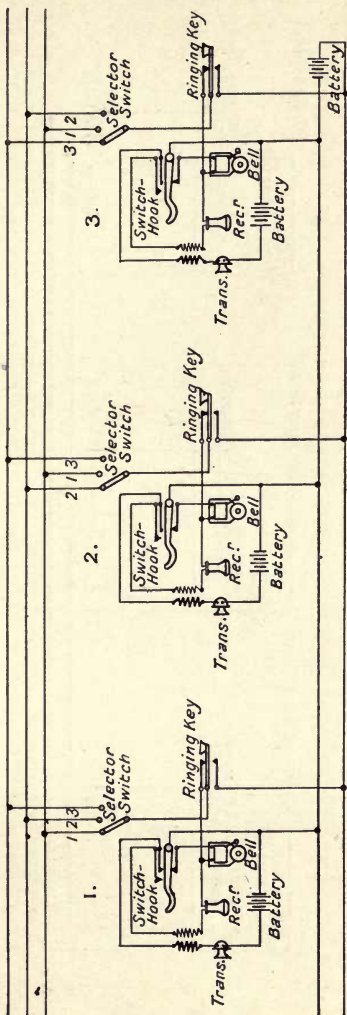
retardation coils would not be required. The wiring then necessary would entail one pair; (the eleventh in colour code) being run from the nearest junction box to the cabinet containing this battery, in addition to a pair of wires from each instrument to its individual battery, located near by. In this case also the ringing battery should consist of 8 dry cells, and the speaking battery of 2 cells for each station connected.

Whichever system is installed the apparatus must be of suitable design, and to this end the purchaser must specify what system he proposes adopting, otherwise there will be trouble, since apparatus designed for local battery systems will not work well on the full central battery system, and vice versa.

(49) VARIOUS INTERCOMMUNICATION SYSTEMS

In Fig. 66 is shown another single wire system with local batteries for speaking, and common battery ringing. Considerable overhearing would be experienced with this system owing to the various line wires not being twisted in pairs; each station, as already intimated, being served by one wire only.

Fig. 67 illustrates the connexions of yet another single wire system, with central battery for both speaking and ringing. Here, again, considerable overhearing will be experienced, due, in the first place, to the line wires not being twisted



All contacts shewn normal as when receiver on sw. hook

FIG. 66.

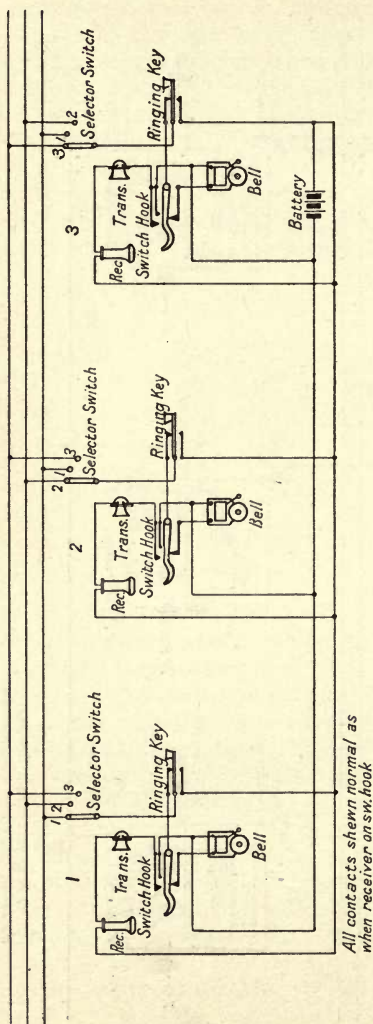


FIG. 67.

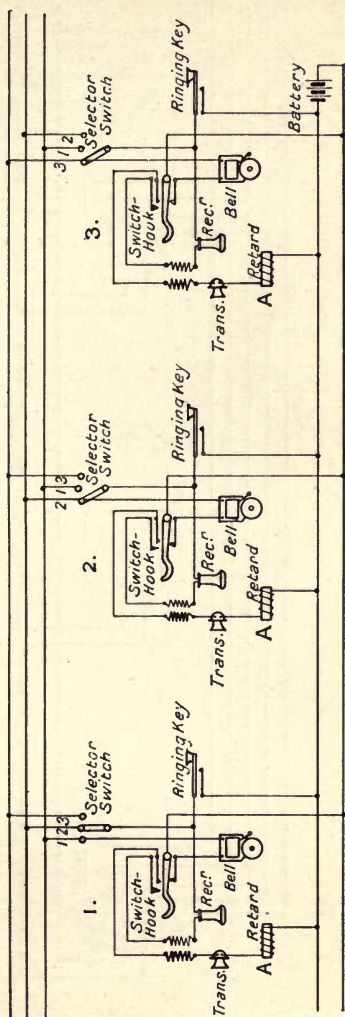
in pairs; secondly, to the return wire being common to all stations; and finally, to absence of balance in the circuits. Some slight improvement may be effected by introducing a retardation coil in series with the circuit as shown at A, Fig. 68.

A very promising single wire system, in which overhearing is practically eliminated, is shown in Fig. 69, the heavy lines indicating the common battery leads, which run to each station throughout the system. It is being exploited by the Automatic Telephone Manufacturing Co., Ltd., Milton Road, Edge Lane, Liverpool, and Fig. 70 shows the inter-

nal connexions of each instrument. When in position opposite the terminal of a called subscriber's line, the Selector Switch is pressed home, and engages with a mechanical locking device, which is automatically released by the replacement of the telephone upon its rest when conversation is finished.

Where over-hearing or cross-talk is immaterial, and the first outlay on plant restricted, the systems outlined in Figs. 67 or 68 may be adopted; but preference should be given to the circuit introduced by the Dean Company, Fig. 63, or the last-named, Fig. 69.

When absolute secrecy is essential, the system



All contacts shown normal as when receiver on sw. hook.

FIG. 68.

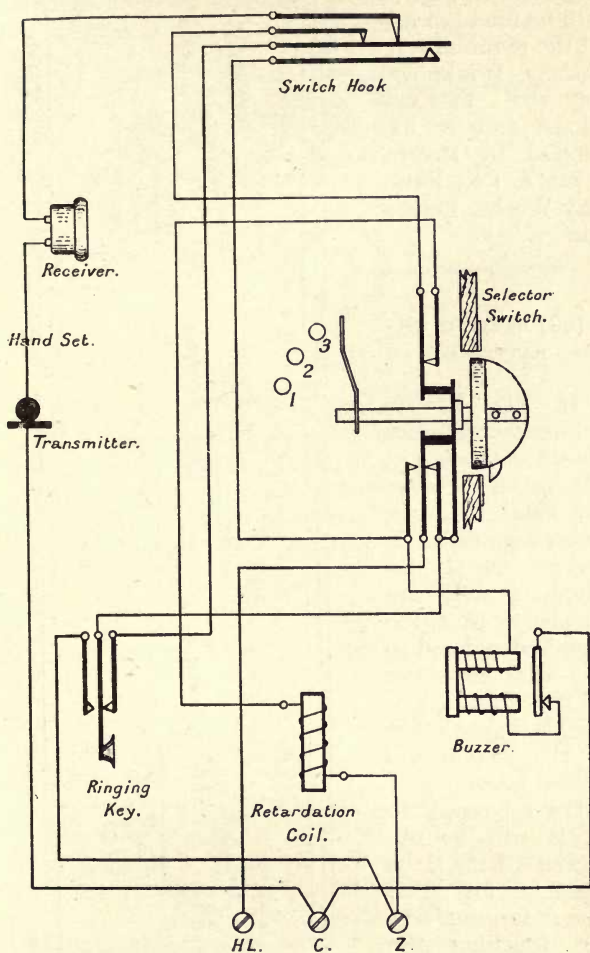


FIG. 70.

depicted in Fig. 71 will be found to fulfil the required conditions. It is known as the Parsons-Sloper and is exploited by Messrs. Gent & Co., Faraday Works, Leicester.

(50) SETTING UP BATTERIES

In Fig. 72 are shown two alternative methods of placing dry batteries side by side, when connected in series. At *A*, individual cells are so placed that the terminal soldered to the zinc container of the first cell is unable to touch that of the second cell in the group.

On reference to *B*, it will be observed that it is possible for this same terminal to be touching the container of the next cell in the group, which would

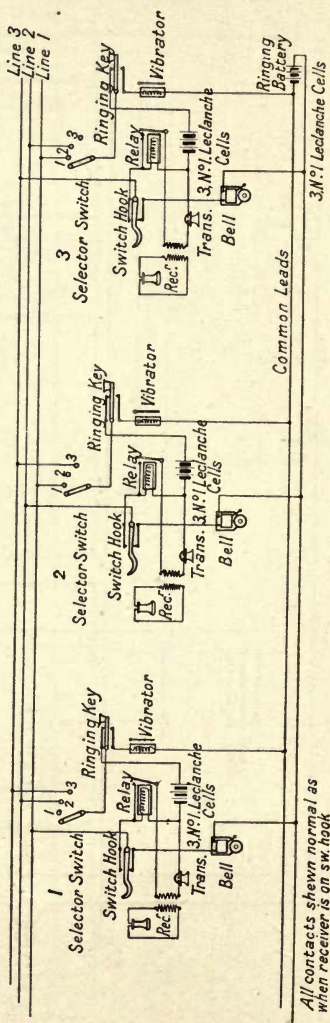


FIG. 71.

be short-circuited in consequence ; obviously therefore the cells in any battery should be placed as at *A*.

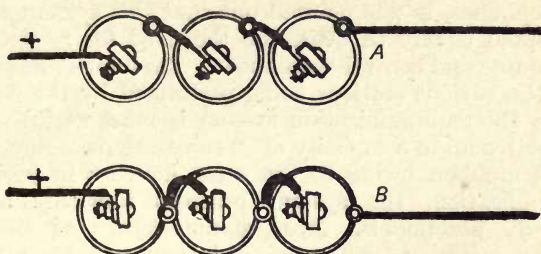


FIG. 72.

(51) CLAMPING WIRES UNDER TERMINAL NUTS

Three possible methods of connecting a wire to a terminal are shown in Fig. 73, at *A*, *B*, and *C*, respectively. At *A* is illustrated the correct method, and it will be seen that in screwing the milled nut home there is a tendency for the wire to bind around the

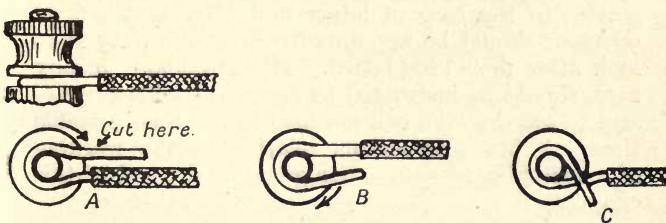


FIG. 73.

threaded shank ; whereas, in *B*, the wire has a tendency to open out, and release itself from under the nut. In *C*, the overlapping portion of the wire will tend to cut into the main wire, and, in any event, the nut will only clamp the top of the overlapping portion instead of the complete turn of the wire around the shank.

(52) TELEPHONE SWITCHBOARDS

In the preceding section on Intercommunication Telephones, it was pointed out that this system was adopted chiefly to overcome the need for a special operator and central switchboard, the inter-switching of the various stations being performed by the user. The Intercommunication system is most useful and effective up to a capacity of 20 sub-stations. Beyond this number, owing to the great increase in wiring complication, the system becomes unwieldy and hardly practicable. Most manufacturers of Intercommunication apparatus endeavour to keep the majority of equipments below the 10-line size. In the Central switchboard system, the wiring and installing item does not bulk so largely, but, on the other hand, the necessary adjunct in the shape of an operator, to put through originated calls, must be taken into account. In the case of small installations, the switchboard should be located in an office, where a junior clerk is stationed whose time is not fully occupied by routine work. To ensure efficient service in the case of larger and busy systems, an operator should be appointed, whose sole duty is to look after the switchboard. The attendant, in any case, should be instructed to answer all calls smartly and to see that the call matures in the least possible time. A few instructions relative to the working of a switchboard system are given at the end of this chapter.

As with Intercommunication systems, there are three or more types of Central Switchboard, viz., (1) Primary Battery, (2) Magneto, and (3) Central Battery systems, with which we will shortly proceed to deal in the order named.

Before proceeding to the installation of apparatus, and wiring, there are a few general remarks which apply in common, and should be borne in mind.

In all telephone systems the main point to con-

sider is the layout, which must be as thorough as possible, since upon this devolves the accurate purchase of apparatus, wire, cable and sundry other items. When the layout has been decided upon, the installer should estimate from it the number of instruments, yards of single or twin insulated wire, and (if the system be partly outdoor) the number of yards of phosphor bronze or H.D. copper wire, etc., and enumerate them in the form of a schedule, which can then be sent out to various manufacturers of good standing for tenders ; it being stated, of course, which system it is proposed to use. In drafting out the scheme, one should start on the lines indicated in connexion with Intercommunication systems. Decide on a point as nearly central to all the sub-stations as possible, and run a cable from it to the switchboard. At the central point fit a junction box ; connect by way of twin, quad, or sextuple wires to the sub-stations and much laborious work, time, and material will be saved. Should faults arise, tests may be made from this junction box to either the switchboard or sub-station side.

(53) WIRING AND FITTING

All indoor wires should run in vertical or horizontal lines and not across corners, but be carried neatly into the latter. Wires should, if possible, be taken along the top, or in the grooves of skirting boards, where they are not likely to be damaged, and fixed by tinned staples driven in at intervals of about 12 in., *between the twist of the two wires*, and not over both, as this latter method, if the staples be driven home, is likely to cut through the insulation and short-circuit them. In a damp situation, too, the staples are liable to corrode and eat through the insulation, ultimately giving rise to the same fault. It should always be the object of the installer to choose a route for the wires remote from any possi-

bility of interference, as it is a most natural failing for persons to handle or to hang articles from them, eventually breaking them down and causing unnecessary faults. The best method of running wires on straight routes, to ensure a neat job, is to staple the wires well at the beginning of the run; then proceed so far, pull the wire taut, and as near its final position as possible, and finally staple well at this distant point also. Intermediate staples can now be driven in and much unnecessary handling avoided. In fitting instruments to walls, a position should be chosen as free from vibration as possible, since the latter in the case of fixed transmitters will tend to set up a frying noise, and speech will be imperfect. The spot being decided upon, the instrument should be fixed at a suitable height for an ordinary person to easily reach the various parts. Allowing about 5 ft. from the floor to the transmitter will usually meet the case. The method of fixing depends on the type of wall. In the case of a brick wall, proceed as follows: arrange the instrument at the required height and mark through the fixing holes, with nails or screws, the points at which wood plugs are to be driven into the walls. Remove the instrument, drill holes, preferably square, and drive in full-sized hard wood plugs. A useful plug for this purpose may be made from broom handles, sawn to the requisite lengths, and shaped. The instrument may now be fixed by screws. In the case of lath and plaster dividing walls, ascertain the position of the lath and secure the instrument by screws, taking care that the latter penetrate through the plaster into the lath. Where wires are taken through damp places they should preferably have a covering of rubber next the conductor, and the insulated wires run through paraffin wax or beeswax; if only one pair be run, wire with an outer waterproof covering should be used. In the case of a number of pairs they should be run in enamelled conduit. In no

case should wires be run nearer to electric power mains than 8 in. Wires in pairs should preferably have coverings of different colours for tracing purposes. Cables should also be constructed with all the pairs of wires differently coloured. In fitting indoor cables it has been found best to run them in electric light casing, but enamelled conduit may be used. The latter method, however, will be more expensive. If price be an object, and the cost of casing prohibitive, then run the cable along near the ceiling, clamping it to the wall at intervals by means of leather strips. If possible, arrange for narrow strips of wood to be nailed to the walls, before fitting the cables. Instructions on the erection of outdoor overhead work are given in a later section, and this will cover, generally, any work that may be required for the systems dealt with in this handbook.

(54) LOCATION OF BATTERIES

The position of the battery for working the various installations depends entirely upon the system and type of instrument adopted, i.e., in the cases of Primary Battery (P.B.) and Magneto. In primary battery installations the batteries may be either at, or near, the central switchboard or at each separate sub-station. With the former arrangement, the cost of upkeep is perhaps slightly reduced by having the batteries centralized, but it will probably be at the expense of less efficiency in speech than is obtained with separate batteries at each instrument. Given good apparatus there is not much to choose between the two alternatives. Again, the central battery arrangement has been rendered more commercially successful by the adoption of electro-magnetic receivers for the sub-stations. In this receiver the polarizing effect similar to that of the permanent magnet in the commonly called "Bell" Receiver is obtained by allowing the direct current, energizing

the transmitter, to flow also through the receiver coil. Variations in the speech currents at the distant end are reproduced through the line in the transmitter and receiver at the home station, thus varying the field of the electro-magnet in this receiver, with the result that vibrations are set up in the diaphragm corresponding with the fluctuations caused by the speaker's voice.

To avoid confusion, it should be understood that primary battery working with a central battery is quite distinct from the system known as Central Energy. In this latter all signals to the Central are automatic, and operate over a very large area, whereas in the former the signalling is manually operated and is only successful over a very small area, a matter of, say, 300 to 400 yards at the very outside, with good line plant. The most efficient area would probably be 100 yards.

The difference in cost between the two systems is also considerable.

Reverting to the position of the battery; where central, this should be fitted in a strong cabinet with hinged drop door, and easily accessible to the person responsible for maintenance. For a system of 10 sub-stations the batteries should consist of two sets of 3-six-block agglomerate Léclanché cells joined in parallel, each set of three cells being in series.

For ringing purposes one set of 4-six-block Agglomerate Léclanché cells will be needed. These also should be fitted in the same cabinet as the speaking battery.

Where a separate battery is adopted for each instrument, these should be located in some out of the way corner fitted either in a box, large enough to accommodate 3 No. 2 Léclanché cells, or in a cupboard near by. Instruments with a special compartment for the battery may be purchased, but these would unnecessarily add to the cost of a system of this description. The battery should be in a cool,

dry position; otherwise, evaporation of the liquid will be promoted. A dusty location should also be avoided. The containing jars should stand so that they do not touch one another, and should be left dry on the outside.

(55) SYSTEM 1. PRIMARY BATTERY, USING SEPARATE BATTERIES FOR EACH SUB-STATION

The system shown in Fig. 74 is probably the simplest in use. Communication may take place between any sub-station and Central, or between any two sub-stations. Any number of sub-stations up to the total number of pairs of the connecting plugs, may be connected at one time. To make a call, press button RB^1 and the indicator drop at switch-

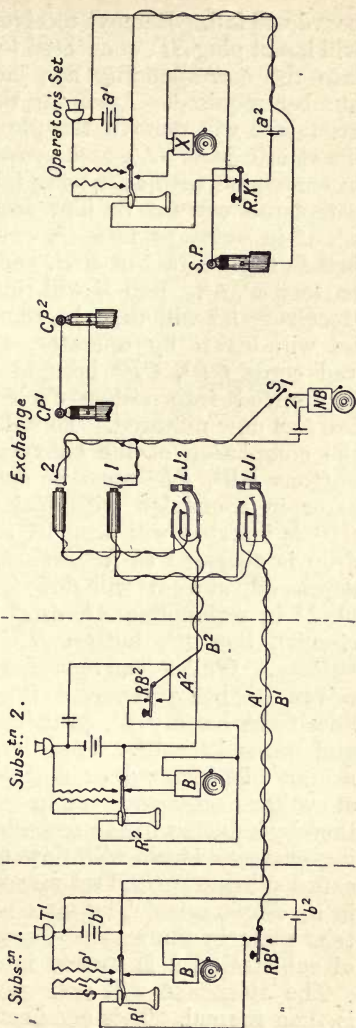


FIG. 74.

board will fall. Remove receiver R^1 . The attendant will insert plug SP , connected to answering telephone, into the corresponding line jack LJ^1 , and ask the number required. Assuming this latter to be 2, the attendant will remove the plug SP from jack LJ^1 , insert into jack JL^2 , and press the ringing key RK , in connexion with answering telephone. This action will cause current to flow from + side of battery, a^1, a^2 in series to line A^2 , switch hook contact and bell B , top contact of RB^2 , and line B^2 , to - side of battery a^1, a^2 . Bell B will ring and call attention. Receiver R^2 will then be removed; plug SP will be withdrawn by operator, and connecting plugs and cords CP^1, CP^2 brought into use. One plug is inserted into either Jack LJ^1 and LJ^2 . The call has now matured. To indicate to the attendant the completion of the conversation, either or both buttons RB^1, RB^2 must be depressed, and the indicator in connexion with jack into which the plug CP^1 is inserted will drop its shutter. This clearing drop is operated as follows—Assume button RB^1 is depressed, current will flow from + side of battery b^1, b^2 in series, line A^1 , drop 1 (bridged across the circuit), line B^1 , button RB^1 to negative side of battery. Whilst conversation is in progress (receiver R^1 being removed from hook) current will flow from battery b^1 , primary P^1 of induction coil and transmitter T^1 . Vibrations set up in the transmitter will increase or decrease its resistance and allow less or more current to flow through the circuit, thereby inducing in the secondary coil S^1 an alternating current, which will flow to the receiver at the called sub-station and set up corresponding vibrations in its diaphragm. The same cycle of operations will take place in the reverse direction when transmitter of sub-station 2 is spoken into.

The attendant will remove plugs and everything is then normal. This arrangement of circuits, using only line indicators for both calling and clearing

purposes, has the advantage of cheapness, as no separate clearing indicator, one for each pair of connecting cords, is required. The indicator left across the speaking circuit does not materially affect the speaking efficiency as it offers a high impedance to alternating speech currents. These indicators, should be of 250 ohms resistance, and, preferably, iron sheathed. In Fig. 75 (A) is shown a slightly different arrangement of switchboard connexions. Each separate line terminates in a connecting cord and plug, which latter is inserted, after the called sub-station has answered, into the jack corresponding

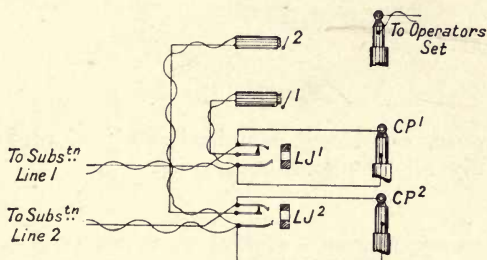


FIG. 75 (A).

with that station, and the same cycle of operations follow as before described. In this switchboard for, say, 10 lines, there would, therefore, be ten plugs and cords, as against six in the previous type of board; that is, allowing 3 pairs of connecting cords, which is usual for a ten-line board of the first type. In Fig. 75 (B) is shown another circuit using separate clearing indicators connected across each pair of connecting cords. An auxiliary bell may be introduced as shown at *NB* (Fig. 74), which will ring when any drop falls. This is useful should the operator have occasion to leave the switchboard. In each type the sub-station and answering instrument connexions remain the same. Should the operator

leave plug *SP* (Fig. 74) in any jack, upon that sub-station again calling, the battery current would ring the bell *X*—the indicator not dropping. All three systems are equally efficient, systems 1 and 2 being, however, cheaper than system 3. The latter

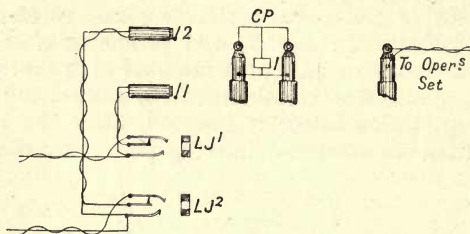


FIG. 75 (B).

is, however, considered standard, and adopted by practically all telephone companies.

(56) PRIMARY BATTERY SYSTEM 2, USING CENTRALLY LOCATED BATTERY

On reference to Fig. 76 it will be noted that the sub-stations are shown without induction coils. This is usually called the “direct” system of working, and, until quite recently, it was necessary to use “Bell” receivers, having permanent magnets as explained elsewhere. Manufacturers have, however, been experimenting to produce a receiver of the purely electro-magnetic type, i.e., without any permanent magnets whatever, and in this endeavour several firms have succeeded. Consequently, it is now possible to use electro-magnetic receivers for “direct” working telephones with great success. In using “Bell” receivers for “direct” working there was a possibility that they might be joined up incorrectly such that the direct current from the

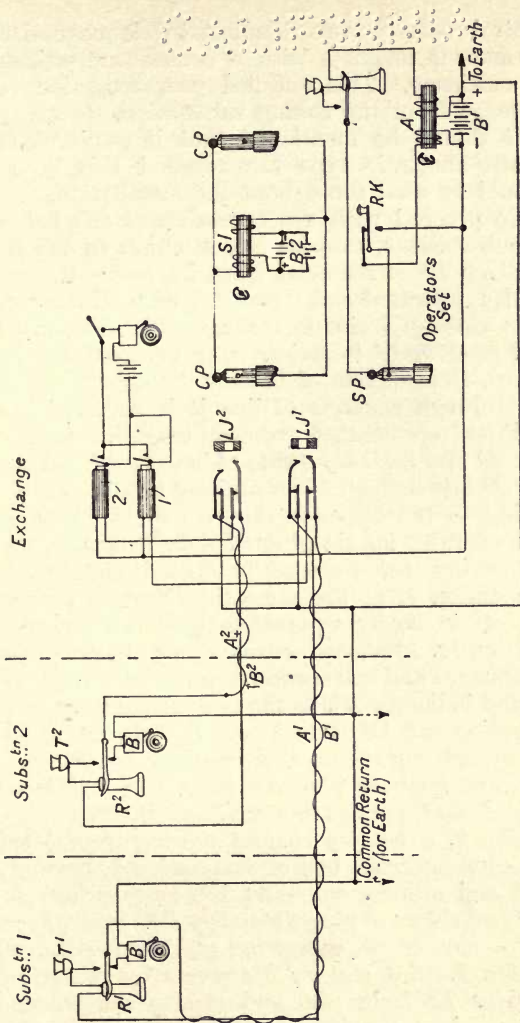


FIG. 76.

central battery was tending to de-magnetize the permanent magnets with a consequent serious loss in efficiency. This entailed poor reception of the message from the calling sub-station.

It should be mentioned that if receivers of the electro-magnetic type are adopted this type only should be used throughout the installation.

To proceed with the operation of the linking-up of sub-stations, suppose No. 1 wishes to call No. 2; receiver R^1 is removed from its rest; the switch-hook is operated and "makes" with its top contact, thus closing a circuit through the transmitter T^1 , and receiver R^1 in series. Current from the switch-board, from + side of battery B^1 now flows to line B^1 , through contacts of line jack LJ^1 , switch-hook and its top contact, transmitter T^1 , receiver R^1 , line A^1 and back to - side of battery B^1 , via contact of LJ^1 and indicator 1, energizing the latter and indicating to the operator that a call has been made. The operator inserts plug SP into jack LJ^1 , thereby connecting the operating or answering telephone to sub-station 1, at the same time cutting indicator 1 out of circuit by separating the inner springs from the outer. Battery current for both operating instrument and sub-station now flows through double-wound indicator A^1 , to the two instruments and conversation can be carried on. Sub-station 1 informs the operator of the number required, i.e., No. 2. The operator removes plug SP from LJ^1 and inserts it in jack LJ^2 , presses key RK , and thereby calls sub-station 2, a battery current flowing from + side of B^1 , common wire, bell of sub-station 2, bottom contact and switch-hook, line B^2 , long spring of jack LJ^2 and sleeve of plug SP to key RK , bottom contact and - side of B^1 , energizing and ringing the bell at station 2. Sub-station 2 answers by removing the receiver R^2 from rest and closing the transmitter and receiver circuit, as previously explained. The operator now removes SP , and inserts plugs CP ,

one in either jack, LJ^1 and LJ^2 , and the call has now matured. Current feeding the two sub-stations is furnished by battery B^2 , flowing via indicator S^1 , which acts not only as a clearing or supervisory indicator to indicate the completion of a call by both sub-stations replacing the receivers R^1 , R^2 , upon their rests, but also as two retardation coils to prevent the speech currents flowing through battery B^2 and giving rise to overhearing. The indicators A^1 and S^1 belong to a type generally known as "drum indicators" and are the subject of a patent held by the Automatic Telephone Manufacturing Co., Ltd. The "drum" or moving portion consists partly of non-magnetic material, and for the rest, of a tapered iron armature, the two combined forming portion of a cylindrical revolving member, which, normally presenting a black surface, level with the surrounding plate, turns, under stress of current passed through its coil, and presents a white signal through the aperture provided. The indicators are extremely sensitive and effective, and operate with very little current. A^1 takes the form of an indicator so that, should the operator inadvertently leave the plug SP in any line jack, the sub-station calling would have a means of attracting attention, otherwise no signal would be given at the switchboard. A retardation coil would suffice for current supply, but there would be no signal to the operator. An auxiliary bell can be connected for operation by the "drum" signals, and would attract attention if the operator left the switchboard.

An elaborated diagram with listening and ringing key in each cord circuit, is shown in Fig. 77. This arrangement saves the plug SP and several of the operations necessary to the circuit shown in Fig. 76.

To answer a call, plug AP (answering plug) is inserted in the jack of line calling, the key having been moved into speaking position, and operating telephone removed from rest. Having ascertained the

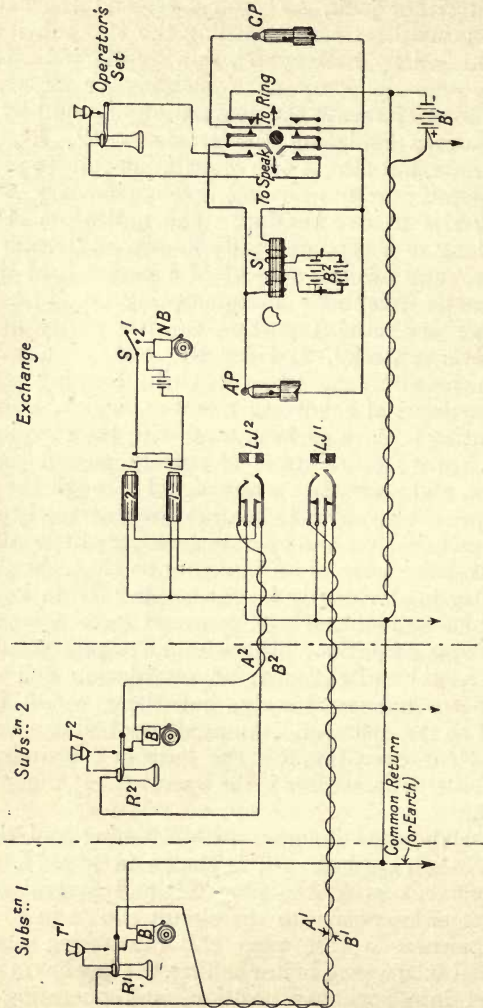


FIG. 77.

requirements of the caller, plug *CP* (calling plug) is inserted into line jack of sub-station required, and the key pressed into ringing position. Upon sub-station required answering, the call is through, *S¹* acting as before as clearing or supervisory indicator.

Batteries *B¹* and *B²* each consist of two sets of cells joined in parallel to obtain low internal resistance. This arrangement is necessary for efficient working if primary cells are used, also to assist in the prevention of overhearing.

(57) MAGNETO SYSTEMS

In the type of switchboard serving sub-station instruments fitted with magneto generators, connexions similar to those shown in Figs. 74 and 75 for primary battery working are used, the difference in the operation of signalling the operator being, that instead

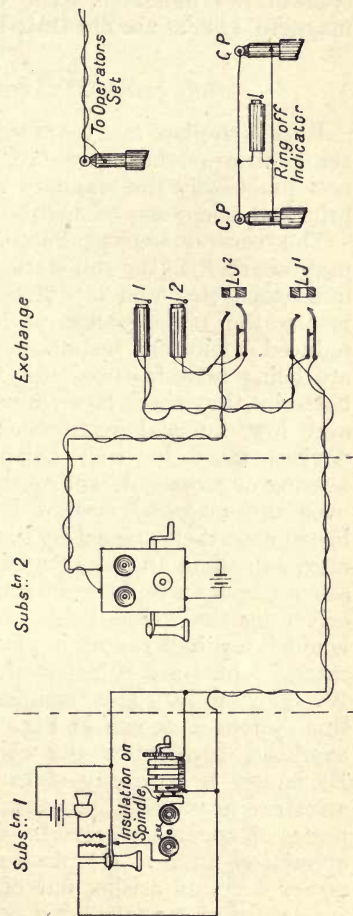


FIG. 78

of pressing a button and allowing direct current to flow and actuate the indicator drop, the handle of a magneto generator is turned, and alternating currents thus generated, which flow to line and similarly operate the indicator. The connexions of such a magneto system are illustrated in Fig. 78.

(58) CENTRAL BATTERY SYSTEM

Within the last few years this system of telephonic communication has made very great strides and is now practically the standard system used by all the principal telephone companies of the world.

The central battery supplies current for every purpose, such as the sub-stations, calling and clearing indicators, etc., and it will be obvious that by this means the maintenance of sub-stations is largely reduced. Efficient installations for small exchanges are being manufactured, for working from primary batteries, but these latter must be of large capacity and low internal resistance; also the inductive devices must be well balanced, otherwise overheating or cross-talk will result. Another advantage over the magneto system is that the sub-station instrument is cheapened by the omission of the generator, as calling and clearing signals to the Exchange are made by simply removing or replacing the receiver on the switch-hook. Switchboard apparatus is much less bulky, and, in place of drop shutter indicators, lamps are substituted, mounted in strips of 10, $\frac{1}{2}$ in. wide. The simplest circuit embodying this system is shown in Fig. 79. In a system with overhead bare wires the cable leading in to the Exchange is generally taken to fuses, lightning arresters, heat coils, and test jacks. These various pieces of apparatus serve to protect the switchboard apparatus from: (1) destruction or damage by power currents arising out of contacts between the bare wires of the telephone system, and electric light

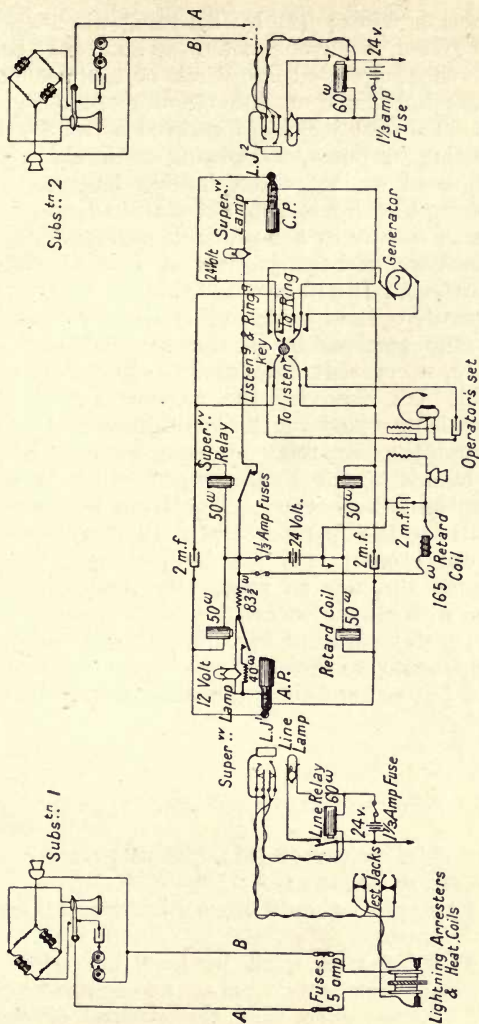


FIG. 79.

or traction wires ; (2) by lightning discharges ; or (3) by excessive currents from the Exchange battery, due to short-circuited line wires, or, in short, external currents heavier than the circuits are designed to carry. The test jacks are inserted as a convenience for testing purposes, tests being made either on the switchboard or line wires, independently.

Tracing the circuit from sub-station 1, the lines are taken as shown to a 5-pt. jack at the switchboard viâ arresters, and test jacks, and thence to line relay and battery. It will be noted that the battery circuit is normally opened at the sub-station by a condenser, when the receiver is on the switch-hook ; consequently, no current flows and the line relay remains normal. On removing the receiver a path for the current is provided viâ the transmitter and induction coil, and the line relay at once operates, closing a local circuit at the Exchange, in which is included a lamp and the battery. The lamp now glows and indicates to the operator that a sub-station is calling. The usual operations for completing a connexion are gone through as previously described in connexion with other systems, and can be readily followed by a careful study of Fig. 79. In the diagram two arrangements are shown for operating the supervisory lamps, but either one or the other should be used in practice.

(59) REQUIREMENTS OF CENTRAL BATTERY SYSTEM

The chief points of this system to keep in good order are as follows :—

1. Line wires should have high insulation resistance.
2. The batteries must be kept in perfect order, and if accumulators are used, must be charged regularly so that the voltage of each cell never falls below 1·8 volts.

3. Overcharging should not be excessive. A good idea of the condition of the batteries may be gleaned from the colour of the plates, that of the positive should be dark chocolate, and of the negative, light grey.

More insight into the working and maintenance of this system may be obtained by reference to one or other of the many handbooks on the subject, as this volume does not pretend to cover the whole subject of central battery exchange equipment, but only in so far as it relates to the installation and connecting up of private telephones.

The installation of sub-station instruments is much the same as on any other of the systems already dealt with.

At the Exchange, however, more care and ingenuity is required than previously. Batteries and charging arrangements have to be provided together with the necessary protection against excessive currents.

(60) ACCUMULATORS AND CHARGING

Briefly, then, the batteries require to be set up in a room adjacent to, but separated from the switch room, as the fumes from the batteries would obviously have a very deleterious effect on the apparatus. Any type of battery selected should preferably be mounted on a wooden stand, and accumulators should be further accommodated upon glass or porcelain insulators.

For the charging of accumulators several methods are available. Perhaps the simplest is to charge from direct current electric light mains through incandescent lamps, the number of these being calculated from the charging current as given by the makers of the battery. A good size of battery for a 50-line switchboard is one of 80 ampere-hour capacity. On a not too busy Exchange, this should supply

current for about three working days before re-charging.

A second method is to charge by motor generator, the motor being wound to suit the supply voltage of any source of electricity supply available on the site, and the generator for a current output equivalent to slightly more than the charging rate of the battery, at a closed-circuit terminal pressure of 30 volts.

A third method, if no supply circuit be available, is to drive a generator of the required output by a gas, steam, or petrol engine, whilst a fourth alternative, if water power be available, is to instal a water-motor for driving the charging dynamo.

The methods of charging enumerated above are in the order of prime cost and maintenance, the first being the most costly, and the fourth cheapest of all.

(61) FUSES

Every circuit requires to be protected against excessive currents, and fuses, switches, etc., should be mounted on a slate panel common to all.

In the discharging circuit from battery to switch-board an elaborate system of fuses is required to protect the various circuits, and these should be arranged as follows :—one $1\frac{1}{2}$ amp. fuse per 50 lines ; one $1\frac{1}{2}$ amp. fuse per cord circuit ; one $1\frac{1}{2}$ amp. fuse for operator's speaking circuit ; and one $1\frac{1}{2}$ amp. fuse for night bell circuit. Fuses of the ordinary type, as used in electric light work, may be used, but are not so effective as those specially designed for telephonic purposes. In the latter the fuse when blown is designed to close an alarm circuit and to actuate a visual signal so that the particular fuse blown can be quickly located.

The fuses are generally mounted on a slate panel and connected to bus-bars. Another bus-bar is added, to which is connected the positive side of battery, and from which wires are taken to the cir-

cuits. From the battery to the fuse bus-bars, cables of as large a cross-section as possible should be provided, so that they offer very little or no resistance. From the fuses, and separate bus-bars, to the various circuit terminals provided on the switch board, wires of 18 or 20 gauge, preferably made up into a cable, should be used.

A type of fuse panel often used for the purpose is illustrated in Fig. 80.

It should be borne in mind that resistance in the leads between the battery and the inductive devices on the switch-board is a fruitful source of that bugbear

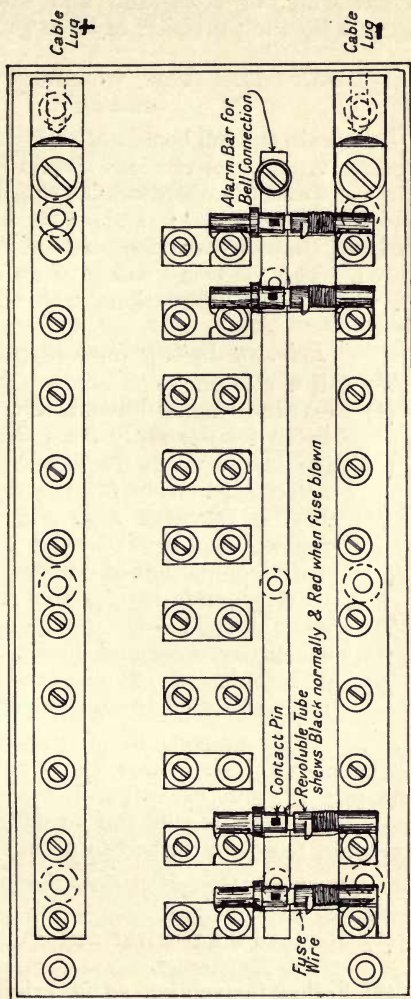


FIG. 80.

overhearing, or cross-talk, and should be guarded against by the provision of large gauge conductors.

(62) INSTRUCTIONS FOR WORKING A SWITCHBOARD SYSTEM

To obtain the full benefit of an Exchange Telephone system explicit instructions should be given both to the users and the operators, as to calling, ringing off, and answering calls; and to make the system a success these instructions should be carefully followed. The following will give an idea of the lines on which these instructions may be drafted:—

Primary Battery Switchboard System

To call a station:—

- (1) Press the ringing button, take up receiver and listen for the reply from the Exchange.
- (2) Give the number required to operator and listen attentively for the called sub-station. If the operator says “number engaged” replace the receiver and call again, later.
- (3) On the completion of conversation replace the receiver and depress the ringing button.

To answer a call:—

- (4) Take up receiver and speak.
- (5) On completion of conversation replace the receiver and depress the ringing button.

Magneto Ringing System

The above instructions apply generally for this system; the only exception being that, instead of depressing a ringing button to call, or ring off, the generator handle is turned to obtain the same result.

Central Battery System

To call a station:—

- (1) Remove the receiver and listen for reply from the Exchange.
- (2) Follow instruction as in primary battery system (2).

- (3) On completion of conversation replace the receiver.

To answer a call:—

- (4) Follow instruction as in primary battery system (4).
- (5) On completion of conversation replace receiver.

Instructions for an Exchange Operator

- (1) Immediately an indicator is actuated, insert an answering or service plug and say "Number please."
- (2) Having ascertained the number required, and, if that number be disengaged, insert the service plug, or the calling plug of a pair of cords, and ring the sub-station by the means provided. If the number be engaged, say "Number engaged" and withdraw the plug.
- (3) On receiving a clearing signal withdraw the connecting plug or plugs.
- (4) If no clearing signal is received after a reasonable time, switch on to the line and ascertain if the conversation is finished.

General

- (1) Speak distinctly but do not shout.
- (2) See that the receiver is not left off the hook when conversation is completed.
- (3) Faults or complaints to be reported to

(63) OUTSIDE LINE CONSTRUCTION

As with interior wiring and installation, a careful layout of the scheme should first be proceeded with, and a plan drawn up of the ground to be covered, with positions of wire routes, poles, chimney brackets, etc., marked thereon. A schedule of all materials required should then be prepared, and prices obtained before placing the order. If it be decided to erect poles to carry the overhead wires or cables, the following brief outline of procedure and general instructions should be followed.

(64) POLES

Creosoted wood poles are generally found to give satisfaction and are probably the cheapest type to employ. They can be obtained in three classes, viz., light, medium, and heavy; the class to be selected depending upon the number of wires to be carried.

Light poles carrying sixteen (40 lb. to the mile) bronze wires, may be spaced at intervals of 75 yards, and in the case of fewer wires, at greater distances apart.

Medium poles, carrying 24 such wires, may be spaced at 65-70 yards, and heavy poles should be used for wire equipments above this number.

Pole holes should be excavated in such manner as to leave an undisturbed vertical wall of solid ground to resist the longitudinal strain of the wires on the pole. Fig. 81 will make this clear.

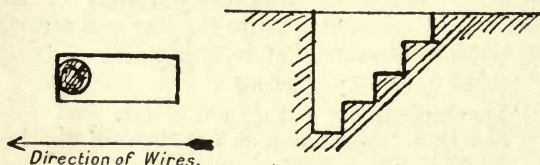


FIG. 81.

The setting of poles in the ground should be to an average depth of 5 to 6 ft., according to length and class of pole, and the character of soil, etc.

In filling in around the pole after erection a good punning should be given to consolidate the loose earth.

The height of the pole should be such that the distance from the ground to the lowest point of the wire in a span is not less than 12 ft. along roads, and 16 ft. over gateways. In crossing roads the lowest point of wires above ground must be not less than 20 ft.

Poles which have wires leaving them at angles to the main route should be well stayed by galvanized steel wire. It is best in any case to stay the poles in a route, at intervals, both fore and aft in line with the route ; otherwise, if the wires in one span are all broken down, it is possible that the stress of wires on the far side may cause the whole route to collapse.

All poles should be fitted with a galvanized iron roof, and, further, be provided with an earth wire, projecting 3 in. above roof, led down alongside the pole and stapled to its butt.

(65) ARMS FOR POLES

are generally of well seasoned oak. They are made in various sizes, to carry 4, and 8, insulators. Holes are ready bored in the arms to take insulator and pole bolts, the former being spaced, between the two outer holes, at 12 in. centres, and between the two inner holes, at 18 in. centres. The arms should be spaced on the poles at 12 in. centres, commencing 8 in. from top of pole.

(66) INSULATORS

The type of insulator most commonly employed in the United Kingdom is the Sinclair. This insulator is constructed with an internal screw thread, and can be easily attached or detached from the bolt.

(67) OVER-HOUSE WIRES

As a rule these are carried on galvanized iron brackets, which are made for supporting either single or double insulators. Eye spikes are also made for carrying insulator bolts to accommodate 1, or 2, wires and are used for terminating overhead wires at sub-stations. The brackets are attached to brick chimneys or walls by clout nails (see Fig. 82), and eye spikes are driven bodily into the wall. A better method for securing these latter is to drill the wall and secure the spike by cement.

The bracket should always be fixed to the wall or chimney so that the pull of the wires is towards the chimney, not away from it.

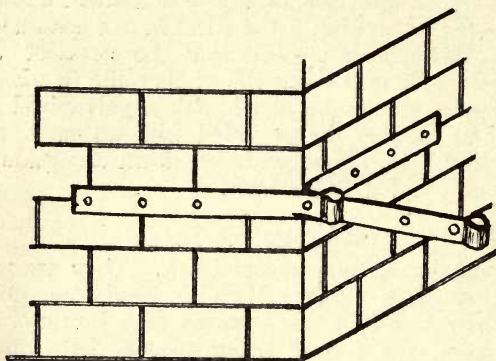


FIG. 82.

(68) ERECTING WIRES

The first wire should be regulated, by means of a dynamometer, according to the following table, which is based on 40-lbs. bronze wire. The other wires can then be erected alongside the first which acts as a guide.

40 LB. BRONZE

SPANS

Tem- perature in deg.F.	50 yards.		60 yards.		70 yards.		80 yards.	
	Sag in inches	Stress in lb.	Sag in inches	Stress in lb.	Sag in inches	Stress in lb.	Sag in inches	Stress in lb.
50	19	13 $\frac{1}{2}$	23	16	27	18 $\frac{1}{2}$	31	20 $\frac{3}{4}$
55	20	12 $\frac{1}{2}$	25	14 $\frac{1}{2}$	30	17 $\frac{1}{2}$	33	19 $\frac{1}{2}$
60	22	12	27	14	31	16	36	18
70	25	10 $\frac{1}{4}$	29	12 $\frac{1}{4}$	35	14 $\frac{1}{2}$	40	16 $\frac{1}{2}$

In pulling up wires great care should be taken to avoid mechanical injury by the draw-tongs or pliers. Kinks should be carefully avoided. When it becomes necessary to cross roads, watchmen should be posted to warn foot passengers, etc. All lines constituting a metallic circuit, i.e., lead and return, should be twisted, a right hand twist being adopted. Fig. 83 illustrates this arrangement, necessary to avoid cross-talk between adjacent circuits. Wires should be kept as clear as possible from the mouths of chimneys, as the heat and constituents of smoke have a very harmful effect on bare wires.

(69) BINDING IN

This should be carried out as follows (see Fig. 84): A soft copper wire

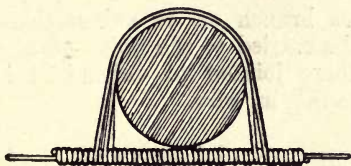


FIG. 84.

is first lapped around the line wire for $1\frac{3}{4}$ in., the ends are then passed round the insulator in reverse directions and under the line wire, round which they are lapped for three turns. They are then crossed back round the insulator and finally lapped round the line wire

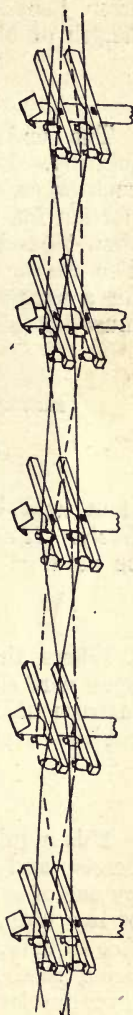


FIG. 83.

from beneath for 8 laps, and cut off flush. The length of binder for 40-lb. bronze wire is 36 in.

(70) JOINTING AND SOLDERING

The ends must be thoroughly cleaned before jointing. Lay the two ends side by side, overlapping each other, say, 8 in., then twist together the centre portion for $1\frac{3}{4}$ in., with a lay of $\frac{1}{2}$ in. Each end is then lapped around the other wire about 4 turns. The centre twisted portion should then be soldered for a space of $\frac{1}{2}$ in. only. In soldering, great care must be taken not to overheat the wire, only suffi-



FIG. 85.

cient heat being required to make the solder flow freely. If a flux be necessary, resin should preferably be used.

(71) LEADING IN

Where the wires branch off to sub-stations the open wire should be carried to the point nearest the instrument and there jointed to vulcanized india-rubber covered leading-in wire.

(72) AERIAL CABLE

This requires very careful handling, to avoid kinks, bends, and twists. The cable may be suspended by one of several types of slings, that preferred being of raw hide. The suspension wire should consist of No. 10 S.W.G. galvanized steel wires, two such wires being used for cables up to 24 pairs of wires and three for larger cables. The slings should be placed on the cable about 3 ft. apart. Care should be taken

that the slings grip the cable tightly. The suspension wires should be thoroughly well anchored to firm supports. One end of these wires should have a swivel stay fitted for tensioning purposes, and this latter secured to the support by stranded steel-wire cable. The distant end of the wires should be fastened round a thimble which should also be secured to the support by steel wire cable. Slack loops of cable should be avoided, as this constitutes a possible source of injury to the wires. When the cable has been erected it should be moderately strained to take up slack and made fast to the supports by means of tarred spun yarn. Never run cable near the mouths of chimneys or in positions where there is a risk of its being chafed by swaying in the wind.

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